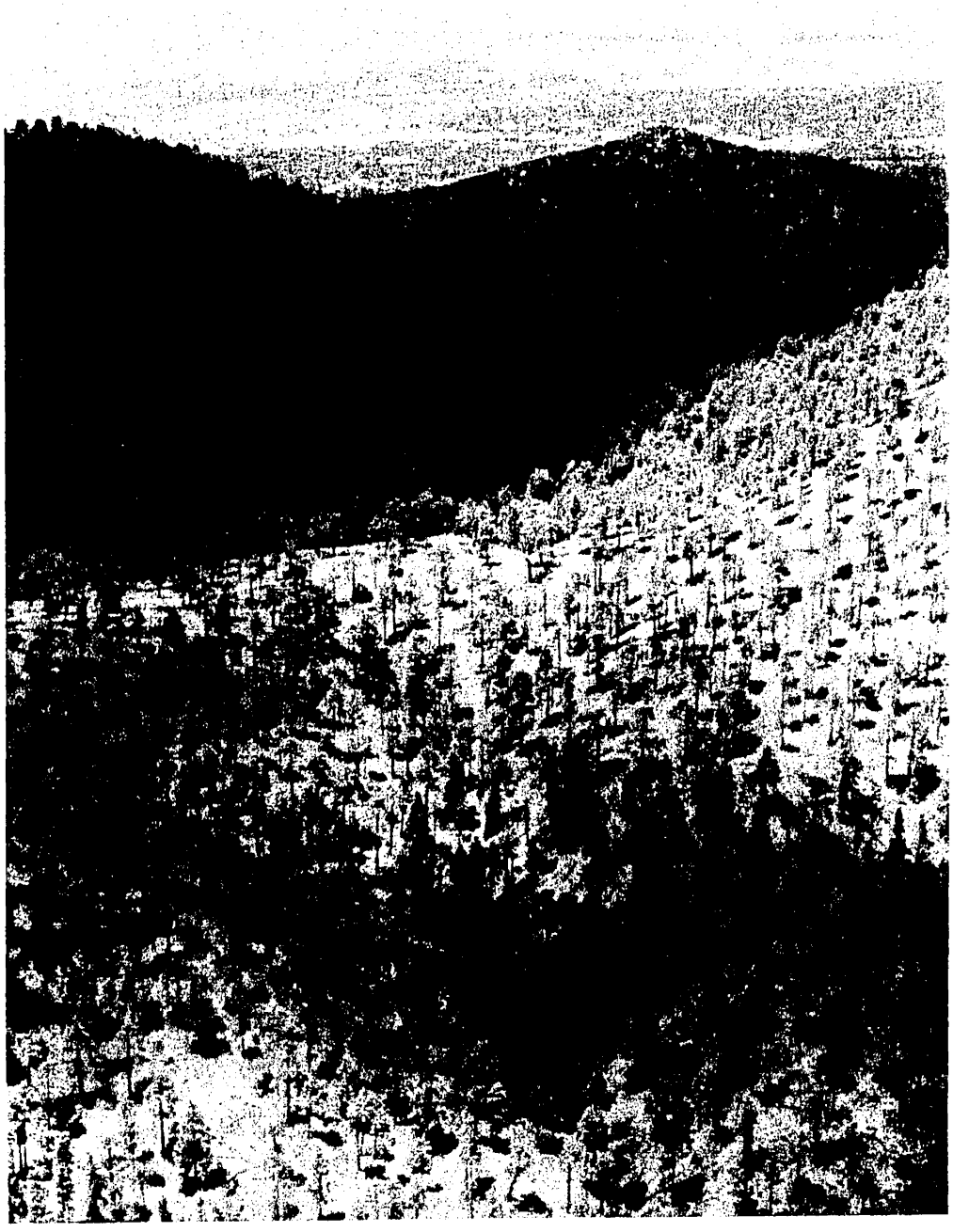
THESIS
REPORTS
SANTA FE

MONITORING FOREST TREATMENTS IN THE SANTA FE MUNICIPAL WATERSHED



Southwest view over thinned area of Santa Fe Municipal Watershed. The ridge trail marks southern watershed boundary; hill in middle distance is Picacho.
Photo: Dr. David Groeneveld, HydroBio, Santa Fe, NM

Monitoring Forest Treatments
in the Santa Fe Municipal Watershed

August 2004

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Monitoring Forest Treatments in the Santa Fe Municipal Watershed

September 2004

Executive Summary

This summary covers a final report by the Santa Fe Watershed Association (SFWA) to the New Mexico Environment Department (NMED) under the terms of a Clean Water Act Section 319 grant. However, as the forest treatments described in the Environmental Impact Statement (EIS) for the Santa Fe Municipal Watershed Project (SFMWP) are roughly two-thirds complete, several more years of post-treatment monitoring and reporting is needed to fully implement the monitoring component of the EIS defining the project. We are seeking funding to continue to monitor, report, and interpret observed data, as well as coordinate a panel of volunteer scientists (the Technical Advisory Group, or TAG) who oversee the data review and interpretation, thus allowing for adequate completion of the project.

In April 2004, TAG held their semi-annual meeting. In this meeting, the committee considered the question: *Should thinning prescriptions be modified to avoid over-thinning, given the likelihood that there will be post-thinning tree mortality caused by beetles or other vectors?* The conclusion was "no": the thinning prescription currently being applied has sufficient margin that some post-treatment mortality brought about by insect attack would not result in excessive openings in the forest. In fact, the creation of a few clearings through beetle kill could result in the restoration of meadow ecosystems that used to be widespread in the mountains between Santa Fe and Pecos, but are now rare.

Also during the April 2004 meeting, the TAG endorsed the Santa Fe National Forest (SFNF) decision to avoid cutting Southwestern white pine in applying forest treatments, in the interest of creating a refuge for that species, having suffering widespread attack by blister rust in the southern part of the state. The TAG also considered a report regarding the potential for identification of beetle-infested trees by use of a listening device to detect the sounds made by the beetles. They recommended the technology be tested further before being promoted for use in the SFMWP.

The TAG now has full representation in all disciplines in which monitoring is being conducted in the SFMWP. However, further expertise in entomology could be useful. The TAG members were asked to consider means to increase TAG participation and to fulfill TAG coordination and reporting functions in the event that SFWA is unable to secure funds to continue these activities. They heard reports of the implementation and monitoring of forest treatments in the SFMWP through spring 2004, which are detailed in the report covered by this summary.

A project implementation team with representatives from the major partners in the SFMWP has met nearly every month since spring 2003 and has succeeded in keeping communication open and the project on track. Thanks in large part to two years of earmarked appropriations for the SFMWP obtained by New Mexico's congressional delegation and the competence of the thinning contractor Forest Rehab, implementation has proceeded more rapidly than anticipated: 3,058 acres have been thinned, much of it using the whole-tree shredding procedure which reduces the need for immediate follow-up burning. In addition, SFNF staff burned 800 acres of slash piles in November-December 2003.

Three years of data on water quality, riparian health, fish populations and geomorphology of the Santa Fe River in the SFMWP reveal little cause for concern. Stream temperatures occasionally exceeded the standard of 20 degrees C, but neither so extended nor so consistent as to present a hazard to fish

populations. Macroinvertebrate and fish populations between the two reservoirs are not as vigorous as in the unregulated section of the river. It has been observed that reservoir operations cause fluctuations in riparian health parameters that may mask changes produced by forest treatments.

The Treated watershed in the Paired Basin study was thinned in April 2004, so this year will be the first year of post-treatment data. Differences in the hydrology between the paired basins will be smoothed through statistical handling of the data in order to recognize any pre/post-thinning response in the Treated basin as well as, in the years to come, recognize any differences in flow, turbidity, and temperature of the Treated versus Control basins that can be traced to the effect of treatments. Two additional precipitation gages have been installed on the upper slopes of the Paired Basins to improve the correlation between precipitation and flow events.

A TAG member has volunteered to model changes in soil erosion potential based on the Universal Soil Loss Equation and post the results to the SFWA website: www.santafewatershed.org. (The full report summarized here, and earlier reports in this series, are also available at the same address.)

Fire/Air: Soil moisture, fuel moisture and weather conditions were monitored in the fall/winter of 2003 to determine when pile-burning was safe. During and after pile-burning in November and December, smoke effects were monitored and compared to ambient air monitoring records: on several occasions, typically during early morning and evening, smoke was detected in the vicinity of Upper Canyon Road at levels "unhealthy for sensitive groups".

Fuels and Forest Vegetation: Stands were delineated to the Stage II Level (units of 10 to 200 acres) in all treatment areas prior to commencement of treatments. The completed Phase I and II treatment areas have also been delineated following treatment, to track changes in density, composition, etc. This information will be integrated with a systematic sampling of forest vegetation and fuels performed in connection with a regional Forest Service exercise in computer modeling of fire risk. The accuracy of these models in predicting fire behavior in the SFMW was put to the test when lightning ignited a fire on the south side of the watershed in summer 2003 and burned about six acres before being suppressed. The conditions that existed at the time of ignition (wind speed and direction, fuel and soil moisture, etc.) were fed into the models, which produced a fire scenario very close to what actually happened.

Data on fuels and forest vegetation is also included as an element of the Rocky Mountain Research Station monitoring program described below. Correlation between the two studies would be desirable.

Researchers from the University of Arizona Tree Ring Lab have initiated a dendrochronological study of fire history and climate in the SFMWP. A report is anticipated in about a year.

Beginning in spring 2003, high mortality due to *Ips* bark beetles has been observed among the piñons on the north side of the Santa Fe River, related to the widespread regional beetle attack in piñon woodlands. There has also been *Ips*-caused mortality among Ponderosa and Southwestern white pines in treatment areas, which may have been exacerbated by the presence of slash, attracting beetles to the area. Overall mortality has been less than 2%. There appears to be significant grass recovery under dead piñons in some areas of the SFMWP.

Rocky Mountain Research Station is in the third year of their study of the effects of fuels reduction treatments in the SFMWP on resident wildlife. Fewer birds were observed in 2003 than in the previous field season: some species had declines between the two seasons, while others increased. These differences may be due to normal fluctuations related to weather and other factors. The data may also be affected by bias and/or inexperience on the part of the technicians making the observations. In contrast to birds, mammalian species diversity has increased overall over time, and arthropod populations have also increased. The results to date do not suggest that wildlife populations are affected by the implementation of treatments nor the treatments themselves. This is by no means conclusive for the overall study, but only for 2003.

The Santa Fe National Forest survey of beaver activity revealed that the lowered reservoir levels in 2003 had caused a lodge and several dams upstream of Nichols Reservoir to be abandoned. However, new dam-building activity was also observed. Beaver had felled nearly all the cottonwoods in two large flooded zones, and are venturing further from the river channel in search of additional food sources. The archaeological/historical study of the watershed noted that beaver were present in the 1930s.

To date, the Santa Fe Municipal Watershed Project has demonstrated:

1. The benefits of a flexible reading of the EIS.
2. The necessity of consistent observation and monitoring of forest treatments, and implementing adaptive management as called for by such observations.
3. An effective model for community involvement.
4. The importance of community involvement to maintain pressure for project implementation (including monitoring).
5. The benefits of keeping our political representatives informed about the project.
6. The need for a coordinator for the monitoring, managing the TAG process and community outreach elements of the project.
7. The fact that the work of collecting, interpreting, and reporting of monitoring data cannot be sustained on volunteer energy alone – it requires a financial commitment and/or motivation through the prospect of publishing results.

Acknowledgements

Coordination and reporting of the monitoring in the Santa Fe Municipal Watershed has been supported for three years under a Clean Water Act Section 319 grant obtained by the Santa Fe Watershed Association in collaboration with the City of Santa Fe and Santa Fe National Forest. Additional funding for Santa Fe Watershed Association's coordination, monitoring and public outreach work has been provided by the Brindle Foundation, McCune Charitable Foundation, Thaw Charitable Trust and a number of individual donors. Without this support, this innovative "community forestry" project would not have been possible. We are most grateful for the opportunity created through these government and private grants.

The following people contributed to this report through their monitoring activities, reports on those activities, or in other ways. Craig Allen, ecologist, arranged for a study of fire history in the Santa Fe Municipal Watershed, and with Thomas Swetnam, director of the University of Arizona Tree-Ring

Laboratory, shared preliminary observations of forest condition and fire history. Gretchen Barkman, SFNF air quality specialist, provided the air quality report. Kevin Buckley and Sam Loftin, TAG hydrologist and ecologist, assisted with modeling soil erosion potential. David Conklin, Forest Service entomologist, contributed his assessment of insect activity. Abraham Franklin, New Mexico Environment Department Surface Water Quality Bureau, is project manager for the 319 grant noted above and is also responsible for most of the water quality sampling and measurements that are needed to assess the condition of the riparian system of the Santa Fe River in the SFMWP. David Groeneveld, principal of the HydroBio consulting firm, donated his time to fly over the municipal watershed and take the cover photograph. David Isackson, SFNF forester, reported on the monitoring of prescribed burning activities. Billy Leonard, wildlife biologist with the Forest Service Rocky Mountain Research Station, directed and reported on the central study of ecosystem effects of thinning and prescribed fire. Sam Loftin, TAG ecologist, prepared the White Paper attached to this report. David Martinez, Forest Service fire ecologist, provided the report on his regional study of forest condition and fire behavior. Alfred Medina, SFNF GIS specialist, provided the map of treatments in the vicinity of the Paired Basins. Mary Orr, SFNF biologist, reported on the beaver population. Steve Thamstrom contributed his photographic expertise, documenting changes in vegetation. Neil Williams, Watershed West, managed the Paired Basin study. Roy Jemison, Research Hydrologist at the Rocky Mountain Research Station, reviewed the statistical potential of the Paired Basin study. Perhaps this list begins to suggest the complexity of the project and the hard work on the part of so many people in bringing it about.

Particular appreciation is due to Bill Armstrong, SFNF forester, for his skill and dedication to the SFMW project since its inception; and to Don Peterson, principal of Forest Rehab, the contractor who has been implementing the treatments prescribed in the EIS more rapidly, sensitively and effectively than anyone had imagined possible.

Paige Grant, Santa Fe Watershed Association, edited and compiled the reports and graphics from the above-named contributors and prepared this and the earlier reports in this series under the terms of the 319 grant. Any factual errors are Ms. Grant's responsibility.

Santa Fe Watershed Association

Monitoring Forest Treatments in the Santa Fe Municipal Watershed

Final 319 Grant Report

September 2004

(To see a map of the treated and untreated portions of the Santa Fe Municipal Watershed please see 'Map or Santa Fe Municipal Watershed Project.pdf", which has not been included in this report since it is a separate pdf file.)

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Attachment A: Participants in April 2004 TAG Meeting
TAG Member Contact List
TAG Process Participants List

Attachment B: White Paper -- Exercise in Adaptive Management: Should thinning prescriptions be modified to avoid over-thinning, given the likelihood that there will be post-thinning tree mortality caused by beetles or other vectors?

Attachment C: Data on water quality and riparian function collected by New Mexico Environment Department in Santa Fe River within Santa Fe Municipal Watershed Project:

C-1: Water Chemistry – Analyte List
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Attachment D: Paired Basin Hydrographs, Water Years 2001 through 2003

Attachment E: Tables and Graphs of 2003 Wildlife Study Results, Rocky Mountain Research Station

Santa Fe Watershed Association:

Monitoring Forest Treatments in the Santa Fe Municipal Watershed
Final status report in fulfillment of 319 grant requirements
September 2004

1.0 Technical Advisory Group (TAG) Deliberations/Recommendations

The TAG and TAG Process Participants met April 22, 2004, at the Barn at Frenchy's Park in Santa Fe, NM. Lists of the meeting attendees, the full TAG and TAG Process Participants are presented in Attachment A.

1.1 Adaptive management in response to beetle infestation. TAG member Sam Loftin led the discussion of his draft White Paper: *Should thinning prescriptions be modified to avoid over-thinning, given the likelihood that there will be post-thinning tree mortality caused by beetles or other vectors?* The group concluded that the thinning prescription has sufficient margin so that some post-treatment mortality brought about by insect attack would not result in excessive openings in the forest. In fact, the creation of a few clearings through beetle kill could result in the restoration of the now rare meadow ecosystems that used to be widespread in the mountains between Santa Fe and Pecos.

Included in the discussion of unintended tree mortality was the issue of Southwestern white pine. For reasons discussed below, the United States Forest Service (USFS) regional forest pathologists requested Santa Fe National Forest (SFNF) project managers to avoid cutting Southwestern white pine in the thinning project. Bill Armstrong, SFNF, and Don Peterson of Forest Rehab, the thinning contractor, stated that Southwestern white pines that occurred in the treatment zones had been protected since the beginning of the thinning project. Armstrong went on to report that white pines were dying anyway, both within and well outside of the treated areas.

Participants endorsed the attempt to protect the Southwestern white pine. The paper was finalized subsequent to the meeting, and is included herein as Attachment B.

After the meeting, David Conklin, forest entomologist for the USFS Southwest Region, visited the Santa Fe Municipal Watershed Project (SFMWP) on May 25, 2004, to evaluate the Southwestern white pine issue. The following is excerpted from this trip report[1]:

> On a previous visit to the project area last September, scattered tree mortality (including several white pines) was observed in the Agua Sarca drainage, which had been hand-thinned and piled in early 2003. Much of this mortality was caused by *Ips* bark beetles and may well have been a result of beetles breeding in and emerging from the pine slash. At that time, we had estimated that no more than one to two percent of the leave trees had died.
>
> Our recent examination found that only minor amounts of additional tree mortality have occurred since last fall. Overall, mortality among leave trees is still probably less than one to two percent. This level of mortality appeared to be no more than (and possibly less than) that which has

[1] 6/2/04 memo to Santa Fe National Forest Supervisor from Debra Allen-Reid, NM Zone Leader, Forest Health, USFS Southwest Regional Office, File Code 3420.

occurred recently in untreated portions of the surrounding landscape. Burning of slash piles over the past winter in the Phase 1 area resulted in significant amounts of crown scorch in some stands, especially where these fires were allowed to "creep" to consume additional fuels. Most of the scorched trees are expected to survive, however. Overall, these fires were probably beneficial.

Figure 1 — Spring 2004 Thinning

The several hundred acres of pine and pine/mixed forest that were hand-thinned late this winter and spring are of some concern, since the fresh slash piles and logs could (again) lead to residual tree mortality from bark beetles. Fresh piles in the Phase 2 area, near the main access road into the Watershed, were found to be heavily infested with *Ips* (probably *Ips pini*). Improved moisture conditions this spring may alleviate the potential for residual tree mortality; however, continued monitoring of these stands is recommended.

The only part of the project area where we found trees recently attacked by bark beetles was in the Phase 4 area, directly across from the Agua Sarca drainage. Here, in an area machine-masticated a few weeks earlier, several standing green piñons had been recently attacked by *Ips confusus*. This is not surprising, given the amount of piñon mortality that occurred in the lower portion of the watershed late last year.

One of the "peripheral" aspects of this project (with fuels reduction being the primary objective) involves the rather large population of white pine in the watershed. Since white pines are immune to the dwarf mistletoes that frequently affect Ponderosa pine and Douglas-fir in this area, they are good trees to retain. Moreover, because the risk of white pine blister rust is very low (due to scarcity of susceptible *Ribes*, the alternate host for this disease), the watershed provides a natural "refugium" for this species, which is threatened by this disease in southern New Mexico.

We are pleased to see that white pine is being favored in the project area, and we continue to recommend that as many of these trees be retained as possible. The majority of the white pines observed in the treated stands appeared healthy, although several had experienced crown dieback, probably drought-related.

Figure 2 — White pines retained in treated stand.

The Phase 4 treatment area will provide additional opportunities to favor white pines. Because these trees can be prone to sun-scald, it should be beneficial to

retain some denser groups of them (where these occur) in the remainder of the project area. Favoring them in the Santa Fe Watershed will nicely support ongoing national efforts to protect and promote white pines.

1.2 Beetle sound recording. Bob Harrill presented information regarding a project that he and his colleague David Dunn had begun just ten days prior to the TAG meeting, involving sound recordings of bark beetles in piñon trees. Dunn, who has worked for many years recording sounds in nature, has developed a listening/recording device that made it possible to detect the presence of beetles in apparently healthy trees. Harrill played a recording of the sounds they had collected, in which "chewing" sounds were clearly audible along with high-pitched squeaks in regular, repeated patterns recognizable on printed sonograms that varied from one tree to another. Bench tests—listening to beetles on piñon pieces in jars—had confirmed that the patterns of sound recordings collected in the field were produced by *Ips* beetles. Preliminary interpretations of the differences in sounds produced were that there may have been *Ips* subspecies involved, or that the insects may have been responding to different stimuli (sending a message that a given tree was fully occupied, for instance).

Harrill canvassed the group regarding whether it would be useful to conduct an exercise using sound recording to identify areas of beetle activity in the SFMWP. After discussion, the group concluded that it may be more appropriate to further develop the experimental design and methodology before introducing it to the SFMWP.

2.0 TAG Role and Decision-making Process

Paige Grant of the Santa Fe Watershed Association (SFWA) reported that the Clean Water Act Section 319 grant that has largely supported the SFWA to coordinate the TAG process, would be fully expended by the end of June. Negotiations are underway with SFNF for a contract for $10,000 to allow the SFWA to continue a portion of its activities. Pending the outcome of obtaining that and/or other funding, however, the TAG and TAG Process Participants were advised to consider how to continue the coordination function that SFWA has provided to date. For instance: Could Los Alamos National Laboratory be approached to authorize a donation of time to the TAG process on the part of one or more of the TAG members who are LANL employees?

3.0 TAG Membership

Thanks to the enlistment of two new TAG members—Kirk Gadzia and Kevin Buckley—the TAG now has at least one member with expertise in each of the subject areas involved in the treatments and monitoring in the SFMWP, with the exception of entomology. Achieving more active participation by members of the TAG at large, however, is an ongoing challenge.

One suggestion made during the TAG meeting for encouraging more active participation was to hold a high-profile professional conference, inviting papers from TAG members and the wider forest science/management community, and publish the proceedings. If the TAG decides in favor of this suggestion, SFWA could approach SFNF regarding use of its $10,000 contract for such a conference. The timing for such a conference is fortuitous, as approximately two-thirds of the project area has been thinned (see Section 4.2) and data collection has been in place for most parameters for three years.

4.0 Coordination of Monitoring with Treatments

4.1 Project management. SFNF initiated monthly "project implementation team" meetings in May 2003. Regular participants include: the City of Santa Fe, SFWA, New Mexico Environment Department (NMED), and staff of New Mexico's congressional delegation, with occasional attendance from USFS Regional Office staff and others. These sessions have allowed for a regular schedule of updates that highlight issues that need resolution and keep the SFMWP moving forward efficiently.

Current Challenges: The project implementation team is focusing on cooperation between the City, County and Forest Service to enforce access restrictions. In particular, the City and SFNF are working to develop a consistent access policy and procedures to permit access on a "need to go" basis. To date, efforts by the group to coordinate with the Pecos District of the SFNF regarding plans for a fuels reduction/forest restoration project in the forest surrounding the SFMWP have had minimal success.

4.2 Treatment status report. The problem of access to the treatment area on the north side of the Santa Fe River was resolved by constructing a temporary bridge across the Santa Fe River below Nichols Reservoir for thinning crews and machinery. This obviated the need for an additional archaeological survey, and allowed work to begin on the north side of the municipal watershed.

SFNF's contractor, Forest Rehab, began thinning treatments in mid-February 2003. At the time of writing, 3,058 acres have been thinned. Thinning has proceeded considerably more rapidly than anticipated, and has extended into areas within the 7,000-acre treatment area that were previously thought to be too steep to permit treatment. Consequently, more of the 7,000 acres may wind up receiving treatment than specified in the original prescription.

Thinning has been conducted both by a crew of up to 50 chainsaw operators operating at a rate of roughly one acre per man per day, and with the use of a track-mounted machine fitted with a grinding/shredding device called a "Fecon head". Variously described as a "shredder", "chunker" or "masticator", this machine can reach to the top of a 20-foot tree and grind it to the ground in a matter of seconds. Taller trees are battered midway up the trunk until the top is felled, and then the top is shredded on the ground followed by shredding the standing bole of the tree.

The shredding is a version of a lop-and-scatter treatment, with the felled trees reduced to chips and chunks ranging from splinters to pieces roughly a foot long and three inches in diameter. The masticated material is broadcast thinly over the forest floor, with no appreciable depth of accumulation; nonetheless, soils appear to remain moist under the shredded material longer than where slash is piled.

The shredding treatment also relaxes the timeline for post-thinning burns, which allows greater flexibility in implementing the treatments. Although it is essential that the shredded areas eventually be burned to maintain the reduced tree density achieved through this treatment, the widely spread shredded material does not contribute to immediate fire danger. Contrast this to slash-piling treatment, where piles must be burned as soon as conditions allow, reducing the accumulation of flammable fuel that they represent. The piles are more combustible than the same materials scattered over the forest floor, due to the fact that the piles are a concentration of fuels stacked in such a way as to maximize ventilation. This provides two of the three elements of the fire triangle, lacking only an ignition source; whereas the shredded

material is less concentrated and more compact, lacking the ventilation factor.

There is considerable heterogeneity within the treated area. Some hillsides are left untouched, with tree densities on the order of 1,000 trees per acre, while firebreaks on ridgelines are thinned to as little as 20 trees per acre. Thinning by hand and by machine has been implemented on slopes up to 40% and even steeper in places. In the hand-thinned units, trunks are left on the ground, where possible across the contour of the slope, to assist in erosion control. In units where the shredder is not used, slash is piled to be burned later when conditions are conducive.

One variant of the cut-and-pile treatment was tried and discarded in 2003. This involved the use of a machine fitted with a "bucket and thumb", which was used to move logs and pile slash after trees had been felled by the hand crew. The use of this machine proved to be less effective than piling by hand.

Burning of slash piles took place in November and December 2003. A total of approximately 800 acres received pile burning treatments (not every acre within that area contained piles). There were no escaped fires associated with the pile burning. Burning was conducted between 10:00 a.m. and 2:00 p.m., and this restriction was effective in managing smoke impacts in the nearest Santa Fe neighborhoods. See Sections 6.4 and 6.5 for reports on monitoring of fire and air quality parameters.

5.0 Efforts to Generate Funding for Monitoring and Coordination

This report constitutes the final deliverable under SFWA's portion of the 2001 Section 319 grant. There are ongoing efforts to generate sufficient funding to continue the monitoring and coordination function of the SFMWP by the SFWA, as well as this series of progress reports.

6.0 "Final" Status Report on Monitoring Forest Treatments in the Santa Fe Municipal Watershed

It is unrealistic to expect that three years of monitoring, of which only the past year included post-treatment monitoring, could "[S]upport conclusions regarding the success or failure of various aspects of the project," as called for in the description of Task 6.6 in SFWA's 319 grant. Instead, this report constitutes a status report that is "final" only in terms of completion of the 319 funding. The need for continued reporting on the progress of implementation and monitoring of the treatments will not end until the area defined in the 2001 EIS for the SFMWP is fully treated, and three to five post-treatment years have elapsed to allow post-treatment assessment under changing climatic conditions.

6.1 Water

6.1.1 Water Chemistry and Santa Fe River Geomorphology. NMED Surface Water Quality Bureau staff collected water quality data from three sites on the upper Santa Fe River from spring 2000 through November 2003. Compilations of these data are presented in Attachment C. The furthest upstream sampling point is near the Pecos Wilderness boundary. The "midway" location is just upstream of the stream gage above McClure Reservoir. The furthest downstream site was initially located at the USGS stream gage between McClure Reservoir and the confluence of Agua Sarca Canyon with the Santa Fe River. This last site was moved in the summer of 2001 to a point downstream of the Agua Sarca confluence and a short distance upstream of Nichols Reservoir. This change was made in order to have a data collection point that was downstream/down-gradient of the area where forest treatments would initially be implemented.

2003 is the first year in which the SFMWP could theoretically have affected water quality. Approximately 1300 acres were thinned in 2003, mostly in the watershed of Agua Sarca Canyon – compared with less than 100 acres thinned in the previous five years.

Chemical Data — In general, water quality in the Santa Fe River within the SFMWP is high. Streams typically become warmer, have higher turbidity, higher conductivity and higher total dissolved solids as they move downhill through their watersheds. It is also typical for solutes to be more concentrated at low flow. These patterns are apparent in the Santa Fe River samples: There are generally higher concentrations between the two reservoirs than at either site above McClure, and usually concentrations are slightly higher at McClure than at the wilderness boundary (see Map of the SFMWP); but the numbers are a good deal higher between the two reservoirs when the flow is at a trickle. This will complicate interpretation of changes in water chemistry at the site between the reservoirs (which is the water quality sampling location that lies downstream of the bulk of the treated acreage) following thinning and burning.

Total Dissolved Solids (TDS) is a measurement of the sum of the major ions that are generally used to define water quality. TDS has never been detected above 180 milligrams per liter (mg/L). By way of comparison, a "secondary" (non-health-related) standard for TDS under National Drinking Water Regulations is 500 mg/L. However, TDS has shown a generally upward trend at the "Below Nichols Reservoir" sampling site, with the highest value to date collected after thinning began in the watershed. Although levels of this analyte are in the same range at all three stations, the other two locations show fluctuating levels rather than an upward trend. Graphs of TDS at the three sampling locations are presented in Attachment C-3.

Of the exhaustive list of organic chemicals – i.e., pesticides and other manufactured hydrocarbons – monitored in the upper watershed from 2000 through 2003, none has been detected. In other good news, mercury has also remained below detection limits in the SFMWP. The complete list of analytes sampled in the SFMWP is included in Attachment C-1, showing which analytes were present above laboratory detection limits. Attachment C-2 compares those analytes that were detected – with the exception of the major ions, for which TDS serves as a proxy measure of the low levels of these constituents – with EPA standards. This filtering process has revealed three parameters that have occurred at levels exceeding EPA standards. Aluminum and iron have occasionally been measured at levels greater than a secondary standard (one that is related to aesthetic or other factors rather than because it impacts human health). Vanadium has been detected at levels exceeding a human health advisory (not an enforceable standard). The source of these minerals is assumed to be natural substrates in the upper watershed, but they have not been directly studied.

Physical Data — Measurements of the Santa Fe River channel were taken to monitor for any change in scour, sedimentation or other parameters resulting from forest treatments. Graphs of the data are presented in Attachment C-5. The cross sections and profiles, when registered and displayed together, do not indicate that any substantial change in the channel shape has occurred at any of the three sites. The characteristics of the channel bed material at the three sites have also remained stable. The measured median particle size of the bed material (the "D50") at the Pecos Wilderness boundary was 62.8 mm in 2001, 45.4 mm in 2002, and 69.7 mm in 2003. The site above McClure Reservoir had D50's of 72.2 mm, 49.4 mm, and 43.7 mm in these

years. Above Nichols Reservoir (and below Agua Sarca Canyon), measured D50's were 20 mm in 2001, 22.6 mm in 2002, and 18.1 mm in 2003.

Thermographs were installed at each water quality sampling point during the summer of 2002 and 2003. The standard for a high quality cold-water fishery (the category applied to the Santa Fe River in the SFMWP reach) of 20 degrees C, was exceeded on two dates at the lower site in 2002; however the assessment protocol, if applied, would have resulted in a finding of full support of the fishery use. Occasional "exceedences" are not sufficient to impair the conditions for fish habitat. The temperature data is presented in Attachment C-4.

6.1.2 Peak Stream Flows in Side Drainages (Paired Basin Study)

History and Objectives of Paired Basin Study -- The Environmental Impact Statement (EIS) for the SFMWP required that erosion monitoring be conducted as one of the primary measures of potential consequences of forest treatments. As plans for the SFMWP were being developed, it was also a matter of interest whether the forest treatments might produce increased runoff.

To answer these and related questions regarding impacts of thinning and prescribed burning in the Santa Fe Municipal Watershed, a paired basin study was initiated by the City of Santa Fe. This study constituted one element of the City's match contribution to the Clean Water Act Section 319 grant obtained in January 2001 by a partnership consisting of Santa Fe National Forest, the City of Santa Fe and the Santa Fe Watershed Association. The engineering firm of Watershed West LLC was contracted by the City of Santa Fe to design and instrument two sub-basins within the municipal watershed and collect and analyze data from the study.

Two contiguous sub-watersheds of 439 and 387 acres respectively, lying between Thompson Peak and the east end of McClure Reservoir, were identified to serve as the study area (see Figure 5 — Paired Basins). The larger, western basin lay within the area tentatively selected for treatment in the draft EIS, and was designated the "Treated" basin; the eastern drainage lay outside of the area intended for treatment, and was selected as the "Control". The two basins appeared to be similar in aspect, forest type and topography. The objective of the study was to compare the hydrologic response of the two basins over time, observing how a representative portion of the Santa Fe Municipal Watershed responded to treatment in terms of:

- Water yield
- Duration of flow
- Peak flows during storms or snowmelt
- Turbidity and sediment production

Instrumentation of the paired basins, data collection and data interpretation is discussed below.

Status of Forest Treatment in the Paired Basins -- About 306 acres of the Treated Basin's 439 acres were thinned in March/April, 2004 by chainsaw crew. The cut trunks were left where they fell, laid across the contour of the hillslope where possible; the extreme steepness of the slope – much of it in excess of 40% --limits this alternative, since the trunks tend to simply roll downhill. The slash (branches and needles) was piled for burning when conditions are conducive (probably winter 2004).

The remainder of the area, approximately 133 acres, was not treated because the slope was too steep to allow access. The relationship of thinned to untreated area in the Treated Basin is 70%; the treatment intensity in the rest of the Phase I project area is about 84%. The density

of trees in the thinned zone of the Treated Basin is approximately 50 to 100 trees per acre, based on preliminary field surveys (personal communication, David Isackson, 9/1/04); tree densities in the unthinned zone of the Treated Basin and in the Control Basin—as well as the rest of the untreated watershed—range from about 500 to 1000 trees per acre, based on the assessment in the EIS.

Data Collection in the Paired Basins – Data collection has been underway in the Paired Basin study since January 2001, so there have been three pre-treatment years to compare the response of the Treated and Control basins under untreated conditions, prior to beginning to watch for any difference in hydrologic behavior of the Treated Basin following thinning and subsequent burning.

Streamflow: Initially, streamflow at the outlet of each drainage was measured using a 30-inch galvanized steel Parshall flume connected to a Design Analysis Water Log central data analysis platform, which also records turbidity and rainfall at 15-minute intervals (see Figure 3). This equipment was installed and began collecting data on January 11, 2001.

Figure 3 — 30-inch Flume Installation

After two years of experience with the 30-inch flumes, Watershed West concluded that they were too oversized for accurate measurement of the minor flows that were typical for the drainages, which have been consistently in the range of 0 to less than 3 cfs. Consequently, on December 3, 2003, 9-inch fiberglass flumes were installed about 25 feet upstream of the larger flumes. The larger flumes remain in place, in order for the turbidity sensors to remain in the same location throughout the study. Also, in the event of changes in the hydrologic regimes, it would be possible to reconnect the gauging apparatus to the larger flumes to measure flows up to approximately 30 cfs with reasonable accuracy. A major fire uphill could produce flows 2 to 3 orders of magnitude greater than the typical trickles out of these small sub-basins; additionally, we should anticipate the potential for higher runoff following thinning and burning in the Treated basin.

Figure 4 — April 2004: Stream gage installation, showing 9-inch flume upstream of 30-inch, plus data logger (tan box cover open)

Turbidity data is collected as a proxy measure of erosion. It also has applications for the City's reservoir management, in terms of maintenance of water quality. Turbidity is measured using a Stevens/Greenspan TS1200 turbidity sensor, which began recording on January 29, 2001.

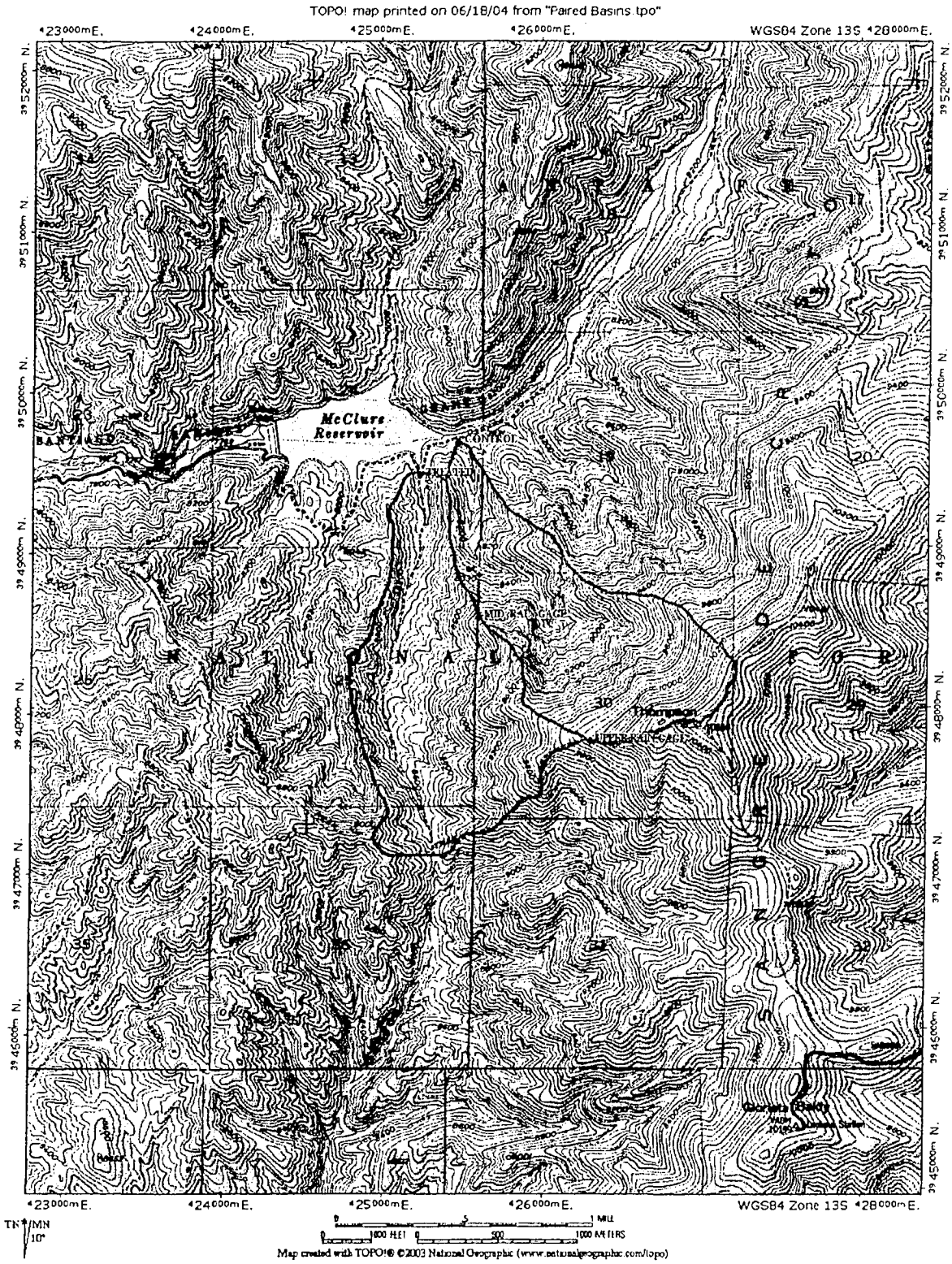
TOPO! map printed on 06/18/04 from "Paired Basins.tpo"
WGS84 Zone 13S
McClure Reservoir
Map created with TOPO!® ©2003 National Geographic (www.nationalgeographic.com/topo)

Figure 5 — Paired Basins

Water temperature has often been observed to rise when the trees shading a stream are removed. Temperature was initially measured in each sub-basin stream using a Thermex temperature probe connected to the central Design Analysis data logger. These probes were replaced in December 2003 with Onset Computer Corporation water temperature loggers, which have built-in data loggers not connected to the central platform.

Regrettably, there are data gaps in the three-year period of record in both sub-basins for both temperature and turbidity, due to equipment malfunction. The faulty equipment has been replaced and full data recovery is expected for the balance of the study period.

Precipitation: Design Analysis tipping bucket rain gages were installed adjacent to each flow gage, connected to the central data logger at each site, in November 2001 (Figure 6).

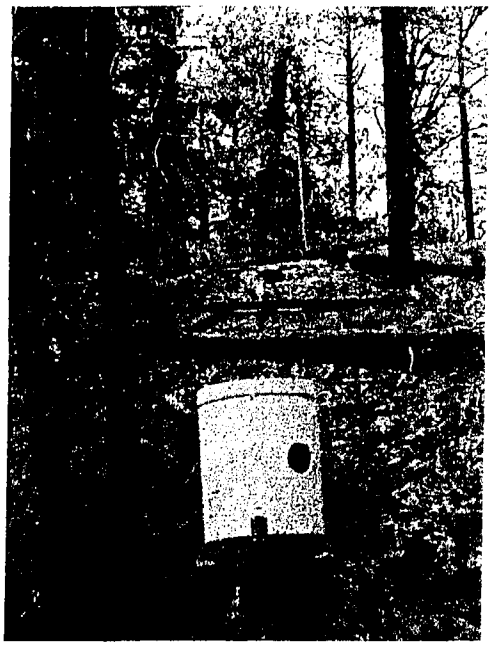

Figure 6 – Design Analysis rain gage, Treated Basin

Subsequently, Watershed West staff and members of the Technical Advisory Group (TAG) observed that the location of the rain gages at the stream gauging sites beneath the tree canopy prevents rainfall from being recorded at the gages even when it is sufficient to produce flow. In addition, convective storms (which produce most of the monsoon rainfall in the Sangre de Cristos) produce very localized precipitation: Rainfall in the upper portion of the paired basins can result in flow at the paired basin outlets that the precipitation gages at the outlets may not register. The TAG has observed repeatedly that it will be possible to draw more robust conclusions from the Paired Basin study with a denser network of rain gages.

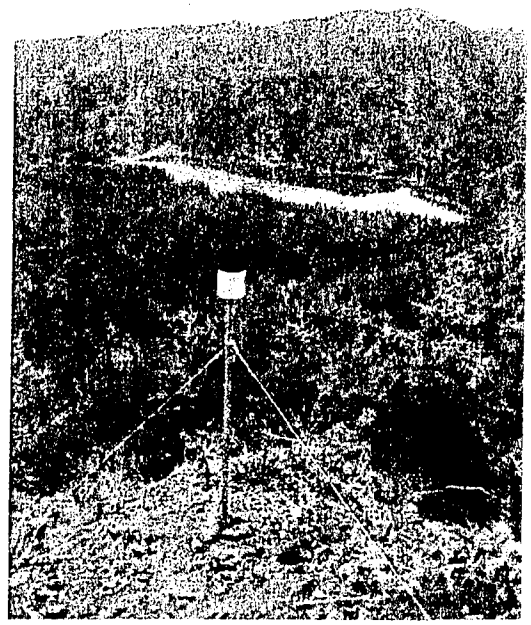

Figure 7 — Mid Elevation (Approx 8,820 ft) Data Logging Rain Gage, May 2004

Consequently, in April 2004, Watershed West installed two additional rain gages at the "uphill" locations shown in Figure 5. These are Onset tipping bucket gages with internal data loggers (Figure 7). They will be visited three times per year to download data and check for any needed repairs.

In addition to the precipitation gages associated with the paired basin study, there are at least two other operating stations in the upper watershed.

At Nichols Reservoir is a RAWS unit ("Remote Area Weather Station") that collects, stores, and forwards data to a computer system at the National Interagency Fire Center in Boise, Idaho via the Geostationary Operational Environmental Satellite. These data are automatically forwarded to several other computer systems. Data collected at the Nichols station include wind speed and direction, air temperature, relative humidity, and precipitation—duration and amount, measured in increments of .01 per hour.

The Natural Resources Conservation Service operates a snowpack telemetry (Snotel) site near the wilderness boundary that includes a precipitation column to measure total rainfall, as well as a snow pillow to record snow accumulations. Data from the RAWS and Snotel stations are accessible at www.wrcc.dri.edu.

Two other tipping bucket rain gages are located at Nichols and McClure dams near USGS streamflow gages, but they may not be in current operation. The City of Santa Fe also carries out manual rain measurements at the water treatment plant near the entrance to the municipal watershed. These data should be useful in developing a relationship between rainfall and elevation for the whole upper watershed area.

Data Summary

The hydrographs in Attachment D present flow and rainfall data from the paired basin study from January 2001 through September 2003. The data are presented by Water Year (WY), from October of one year through September of the following year. WY 2001 is only partly represented (January through September); WY 02 and WY 03 are complete. The current WY 04, beginning in October 2003, will be the first to show post-treatment data.

On comparing the flows from the Treated and Control basins it is readily apparent that, for the entire period under study, the Control basin has flowed on a more sustained basis than the Treated basin. Possible explanations for this include:

- The Control basin rises to a higher altitude than the Treated basin. This would position it to receive more precipitation.
- The Treated basin is oriented more southwesterly, which may result in greater evapotranspiration.
- The Treated basin, which is larger than the Control by about 52 acres, is more heavily forested than the Control. In addition, the Control basin includes a large scree slope bearing no vegetation. These factors may also result in higher evapotranspiration from the Treated basin.

It is common in paired basin studies that the two sub-watersheds being compared do not behave identically: Landscape does not tend to occur in exactly comparable units. Statistical analysis is required to analyze the hydrology of a pair of sub-watersheds relative to each other, so that it is then possible to recognize changes in the response of the basin receiving the altered treatment (see below for further discussion). It is nonetheless possible to recognize some trends in the data:

- All parameters are within the same range within the two basins: i.e., one does not produce substantially higher flows or greater turbidity than the other under pre-treatment conditions.

- Turbidity is higher in response to summer flow events than snowmelt events.

- A spike in turbidity can be generated by a rainfall event that is insufficient to generate much of an increase in streamflow. In other words, overland flow appears to flush sediment to the stream without increasing the flow in the stream to dilute those sediment inputs.

- Precipitation events and streamflow events appear to correlate fairly closely, although, as noted above, flow in the Control basin is more sustained.

Further Analysis Required –

Hydrology: Roy Jemison a statistician at RMRS states that statistical analysis will be used to interpret pre and post runoff data to determine if there are significant changes in runoff characteristics as a result of the treatments. Statistical methods that can be used with the data being collected include: Repeated Measures Analysis and Analysis of Covariance. Changes in runoff characteristics that could occur as a result of the treatments include decreased time to peak flow, decreased duration of runoff events and increased soil surface and channel erosion until some form of ground cover is established.

Turbidity: Watershed West plans to conduct sampling during the rising stage of storm events at each streamflow measuring station in order to collect sediment samples for purposes of calibrating the turbidity data collected to date. Correlating suspended sediment samples with turbidity measurements will help to establish a relationship between turbidity and the fine, suspended portion of sediment eroding off the sub-basin hillslopes. However, it will not measure the bedload portion of that sediment movement. Other approaches to analyzing soil erosion will be required to address that issue.

6.2 Soil

An attempt was made to follow the protocol outlined by the TAG in the White Paper "Soil Erosion Modeling Project" (see March 2004 TAG report), involving creating a spreadsheet to calculate changes in soil erosion potential based on changes in vegetative cover. TAG Member Bill Fleming made it a project in his UNM Watershed Management class in the spring 2004 semester, with assistance from other TAG members, TAG Process Participants and SFWA staff to develop the protocol and locate data sources for the terms in the USLE equation. However, given academic deadlines to complete and present a project before semester's end, the analysis was not prepared. We continue to seek a way to carry out this project. When results are available, they will be posted on the SFWA website: www.santafewatershed.org.

Regarding turbidity and soil Jemison adds: Erosion pins can be used to get a relative idea of soil movement on the watersheds. Erosion pins can be as simple as large spikes with washers on them. The washer is placed around the spike and then spike is inserted into the ground. The washer is left on the soil surface and the height from the washer to the top of the spike is recorded. As soil is eroded from the site by runoff, the washer drops down. If soil deposition takes place, the washer becomes buried. The sites can be measured after each precipitation event, monthly, or at whatever time period is convenient. These data could be correlated with the precipitation data to estimate effects of rainfall intensity on soil detachment and movement on the watersheds.

6.3 Ground Vegetation

See **Wildlife Populations: Biological Diversity**, Section 6.8.4.

6.4 Fire

David Isackson, SFNF Española District,

provided the following report: During the 17 days that piles were burned during the months of November and December 2003, the Energy Release Component (ERC), Keech Byram's Drought Index (KBDI) and fuel moistures (FM) were monitored using data from the Remote Automated Weather Station (RAWS) units at Nichols Reservoir and in the Pecos drainage. RAWS units do not record the Palmer Drought Index, as indicated in the EIS monitoring plan, but instead monitor KBDI. This is the reason for the switch in drought index monitoring. KBDI is on a scale of 0 to 800, zero being the point of no moisture deficiency and 800 the maximum drought possible. ERC units run from 0 to 82: 0 to 35 indicates low fire danger, and values above 66 indicate very high to extreme fire danger.

The following table shows results for these parameters on days when burning occurred in the watershed. Note that 1,000 hr fuel moisture is reported to be less than 100 hr fuel moisture for some days. This is probably due to inaccurate measurement by the RAWS unit: the rule of thumb is that adding 2 units to the 100 hr fuel moisture gives the 1,000 hr fuel moisture.

Date	KBDI	ERC	1 HR FM	10 HR FM	100 HR FM	1000 HR FM
11/14	87	48	8	9	13	11
11/15	52	51	5	7	16	12
11/16	41	45	6	8	17	13
11/18	36	45	5	7	18	14
11/19	37	53	4	6	14	14
11/20	39	59	3	5	11	14
11/21	40	59	4	5	9	14
12/1	49	69	5	5	6	10
12/2	50	70	4	5	7	10
12/3	51	74	3	4	6	10
12/4	51	82	1	2	6	10
12/10	55	66	2	4	12	11
12/11	55	67	3	4	9	11
12/12	55	47	10	10	10	11
12/16	55	57	4	6	13	12
12/17	55	66	2	4	11	12
12/18	56	65	3	4	9	12

6.5 Air

The following report was prepared by Gretchen Barkmann, SFNF.

An ambient air quality monitoring station has been established at the old Two Mile Reservoir Dam site (corner of Cerro Gordo Road and Upper Canyon Road) on land owned by the City of Santa Fe. The Forest Service maintains and operates the site.

Two filter Federal Reference Method (FRM) instruments and one real-time instrument have been used to collect baseline data and data during burning. All instruments sample the concentration of $PM_{2.5}$ (particulate matter less than 2.5 microns in diameter). Only preliminary data has been received from the lab for the runs on the filter FRM instruments. This is due to language in the contract with the lab, which specifies that the final report will be submitted once the contract has been completed. The runs made to date have been shorter than anticipated, which left unused filters, and the contract is still open.

Data described below is from DataRAM D104, the real-time instrument. Real-time data is not a direct measurement of particulate matter and therefore can only be considered an estimate. Studies have shown that these particular real-time instruments overestimate particulate concentration by 30-60%. Comparison of the preliminary data from the filter instruments indicates that the real time instrument used at this site overestimates by 52%. For the runs conducted in November and December 0f 2003, the calibration factor on DataRAM D104 was set to 0.48, in an attempt to bring the recorded values closer to those recorded by the FRMs.

There was no air quality monitoring from March to November 2003 because there was no burning in the watershed. Burning was conducted in November and December 2003.

Three different data sets were obtained from the real-time instrument. These datasets cover the periods November 14-24, December 1-9 and December 9-22. The following tables summarize 24-hour average and one-hour average concentrations of $PM_{2.5}$ as recorded by DataRAM D104. Values in the table are those that exceed the Air Quality Index rating of "Good".

The 24-hour average concentration of $PM_{2.5}$ never exceeded the federal standard of 65 $\mu g/m^3$ and only reached about half of that value on November 22.

The one-hour average concentration exceeded the rating of "good" a number of times, reaching into the "unhealthy for sensitive groups" on Nov 21 and 22.

A summary of **24-hour average $PM_{2.5}$** concentrations, recorded by DataRAM D104, with Air Quality Index rating exceeding "Good" follows:

24-hour interval	Average µg/m3 $PM_{2.5}$	Air Quality Index Rating
19-Nov	19.6	Moderate
20-Nov	20.7	Moderate
21-Nov	27.1	Moderate
22-Nov	33.4	Moderate

A summary of **one-hour average $PM_{2.5}$** concentrations, recorded by DataRAM D104, with Air Quality Index rating exceeding "Good" follows:

Date	One-hour interval	Average µg/m3 $PM_{2.5}$	Air Quality Index Rating
Nov 16	1700-1800	61.7	Moderate
	1800-1900	64.1	Moderate
Nov 19	1800-1900	59.4	Moderate
	1900-2000	56.1	Moderate
	2000-2100	51.2	Moderate
	2100-2200	46.6	Moderate
Nov 20	2300-2400	51.8	Moderate

Date	One-hour interval	Average µg/m3 $PM_{2.5}$	Air Quality Index Rating
Nov 21	1700-1800	121.7	Unhealthy for sensitive groups
	1800-1900	104.3	Unhealthy for sensitive groups
	1900-2000	102.8	Unhealthy for sensitive groups
	2000-2100	111.3	Unhealthy for sensitive groups
	2100-2200	73.5	Moderate
Nov 22	0000-0100	53.6	Moderate
	0100-0200	105.0	Unhealthy for sensitive groups
	0200-0300	87.2	Unhealthy for sensitive groups
	0300-0400	70.7	Moderate
	0400-0500	64.3	Moderate
	0500-0600	62.7	Moderate
	0600-0700	43.6	Moderate
Dec 1	2000-2100	45.3	Moderate
	2200-2300	46.1	Moderate

Smoke was rarely visible during the day, as daytime winds usually carried the smoke to the northeast. Daytime smoke was visible on December 1 when the more southerly winds carried the smoke along the foothills over the Hyde Park area. There was one reported case of an asthma attack due to this smoke event. Most of the recorded exceedences of "Good" Air Quality Index happened in the evening or early morning hours, a result of residual smoke flowing down the Santa Fe Canyon into the Upper Canyon Road area.

A summary of the elevated concentrations recorded at five-minute intervals follows:

- November 16 from 17:10 to 19:05 with a peak of 89.2 $\mu g/m^3$ at 17:20
- November 19 from 18:10 to 22:20 with a peak of 89.0 $\mu g/m^3$ at 18:45
- November 20 from 18:46 to 00:10 with a peak of 58.5 $\mu g/m^3$ at 23:15
- November 21 from 17:05 to 21:40 with a peak of 188 $\mu g/m^3$ at 17:30
- November 22 from 00:30 to 06:40 with a peak of 146.1 $\mu g/m^3$ at 00:55
- December 1 from 18:57 to 05:38 with peaks of 56.6 $\mu g/m^3$ at 19:03 and 55.6 $\mu g/m^3$ at 01:18
- December 9, brief peak of 70:7 $\mu g/m^3$ at 09:33
- December 19 from 18:34 to 20:29 with a peak of 46.3 $\mu g/m^3$ at 18:44.

Runs conducted in 2002 and early 2003 indicate that background $PM_{2.5}$ over Upper Canyon Road is less than 2 $\mu g/m^3$ as a 24-hour average, and elevated 24-hour average $PM_{2.5}$ concentrations from non-burning activities generally reached less than 20 $\mu g/m^3$. The runs from November and December 2003 indicate that pile burning does increase $PM_{2.5}$ in ambient air over Upper Canyon Road for short periods of time in evening hours.

6.6 Fuels & Forest Vegetation

6.6.1 Baseline/followup data. The EIS monitoring plan specifies stand exam plots and stratified random sampling to measure basal area, trees per acre, diameter class distribution and percent canopy cover. Photo points are called for to further document changes in density and distribution of trees over the landscape.

Stands were delineated in all treatment areas prior to commencement of treatments, to the Stage II Level (units of 10 to 200 acres). Phase I and II has also been delineated following treatment to track changes in density, composition, etc.; George Alter, SFNF Silviculturist, has this data. This information will be integrated with a systematic sampling of forest vegetation and fuels described below.

David Martinez, Fire Ecologist with the Southwestern Region of the Forest Service, reports that he and the Regional Fuels Crew established permanent monitoring points in the SFMWP during July 2002. These plots are intended to monitor hazardous fuels pre- and post-treatment, facilitate adaptive management strategies and provide base-line information for computer modeling applications.

Survey points were installed in areas to be treated south of the Santa Fe River and reservoirs. A total of 50 points were sampled in 17 stands. A minimum sample size of two points was established for each stand. Points were located in three cover types: Ponderosa Pine (37), White Fir (8), and Douglas Fir (5). Survey points consisted of three concentric fixed-radius plots and a Brown's planar intersect dead and down transect. A $1/300^{th}$ acre plot was used to tally regeneration of tree species. All trees with a DBH/DRC <2 inches or <4.5 feet tall were recorded by species. A $1/10^{th}$ acre plot was used to record data on all individual trees >2 inches DBH/DRC. For each tree DBH/DRC, height, crown height, crown ratio and crown class were recorded. Crown height was defined as the lowest live branch. The presence of mistletoe or insect infestations was also noted. A $1/4^{th}$ acre plot was used to record all snags >2 inches. For each snag, DBH/DRC and a snag class were recorded. A Brown's transect was laid out in a random direction from each point. Information was collected on duff and litter depths, 1-, 10-, 100- and 1,000-hour fuels.

Additional information including slope, aspect, fuel model, existing vegetation, potential vegetation and GPS coordinates were recorded. Record photos were taken in the cardinal directions and of the fuels transect. A hemispherical photo was taken of canopy cover.

All data collected was entered into FSVeg under the project name "SF WATERSHED". Data will be analyzed using FARSITE, the crown fire behavior model NEXUS, Fuels Management Analyst Plus, and the Integrated Forest Management System (INFORMS)-Fuels Reduction Analysis Package (following system installation). A more in-depth analysis will be accomplished using the Forest Vegetation Simulator (FVS), Stand Visualization System (SVS), and the Fire Area Simulation Model (FARSITE). Canopy cover will be calculated using Gap Light Analyzer (GLA) and the hemispherical photos.

The accuracy of these integrated models in predicting fire behavior in the SFMW was put to the test when lightning ignited a fire on the south side of the watershed in summer 2003 and burned about six acres before being suppressed. The conditions that existed at the time of ignition (wind speed and direction, fuel and soil moisture, etc.) were fed into the models, which produced a fire scenario very close to what actually happened. The intention of the modeling exercise is to highlight areas that are at high risk for major fire, so that treatment can be concentrated in those areas. However, there may be a disconnect between the researchers creating this powerful tool, and the managers who will have to make the decisions about where to focus fuel reduction project funds.

Data on fuels and forest vegetation is also included as an element of the Rocky Mountain Research Station monitoring program described below under *Wildlife Populations: Biological Diversity*. At a minimum, locations of the data collection points in the Martinez study should be correlated with the RMRS data points. Further correlation between the two studies would be desirable.

Steve Tharnstrom is providing an important contribution to photo documentation of the changing condition of the SFMW. In connection with a SFWA planned book on the history of the watershed of the Santa Fe River, Steve has performed a thorough archival search for historic photographs of the whole watershed, from Lake Peak to the Rio Grande. He has identified the locations of many of the old photographs and visited the sites with a large-format camera to reshoot photographs of the identical scene. His work includes providing copies of the old photographs and his retakes, together with precise location information, to an archive compiled by Craig Allen, USGS, based at Bandelier National Monument (see below). Steve also created a guidance document for improving the use of photo points by various managers and researchers in the SFMWP.

6.6.2 Fire History of the SFMW. Thanks to the efforts of Craig Allen, USGS, in securing funds for the work, a dendrochronological study of fire history and climate is being conducted in the Santa Fe Municipal Watershed. Researchers from the University of Arizona Tree Ring Lab began fieldwork in June 2004, and a report is anticipated in about a year.

Preliminary observations by Thomas Swetnam, Craig Allen and other researchers indicate a substantially different fire history between at least parts of the watershed area on the south side of the Santa Fe River, versus the north side. In the areas visited to date, fire scars in trees on the south side are relatively fewer than on the north side: typically two scars in two- to three-hundred-year-old Ponderosa, Douglas fir and Southwestern white pines on the south side, as opposed to eight or more on the north

side. Possible reasons include differences in soils; more south-facing (hence drier, more fire-prone) terrain on the north side; and perhaps earlier grazing on the south side, which was more readily accessible to Santa Fe (thus, the understory that would carry a ground fire had been rendered more sparse as early as the mid-18th century). As sampling begins, the trees will undoubtedly elaborate upon and refine the story of this landscape.

The research team is particularly interested in assessing the fire history in the wilderness portion of the watershed (See Map of the SFMWP). In this area, Ponderosa forest grades into western mixed conifer and spruce-fir forest types, which tend to burn in stand-replacement fires at intervals of two to three centuries or more. Swetnam and Allen expressed their concern that the tree density in that portion of the watershed, combined with the apparent lack of any significant fire for well over one hundred years, is highly conducive to crown fire; and that a major fire in that steep landscape would unquestionably result in substantial flooding and sediment movement in the watershed.

6.6.3 Demonstration Plot Mortality Study

Four demonstration plots west of Nichols Reservoir totaling about eight acres were thinned in the fall of 1999, and subsequently burned in May of 2001, to illustrate to decision-makers and the interested public what the Forest Service proposed as treatments over a larger area in the municipal watershed.

College of Santa Fe students led by TAG Process Participant Bob Harrill collected data from the two contiguous westernmost plots in the 2001 and 2002 growing seasons. Each tree, cut and standing, was plotted on a map and identified to species. Data recorded included diameter, and for standing trees the percent of green needles in the crown.

Although based on a limited sample, the data suggested that the "pile" unit suffered greater post-treatment mortality than the "scatter" unit. This preliminary information became an exercise in adaptive management. One outcome of the discussion of the demo plot mortality was to adopt the Fecon head/shredding technology for use in the SFMWP, in part to avoid the mortality caused by burning of piles located close to remaining trees.

No further study of the demo plots is planned.

6.7 Forest & Riparian Vegetation

6.7.1 Invasive plants. The monitoring plan calls for a survey of invasive plants in the Santa Fe River canyon two to three years after treatments are initiated. Treatments are not proposed for the riparian area, but uphill treatments may have detectable impacts on the riparian zone. Since treatments have only begun to affect a significant area starting in February 2003, it will be necessary to organize this effort in spring/summer 2005. Baseline data on invasive species are available from the 1998 Tolisano report to SFNF, on which the Existing Conditions report (1999) was based.

During the survey of beaver activity conducted in August 2003, a colony of the noxious weed Toadflax was observed and flagged so that it can be mapped as part of an overall invasive species management plan. A Draft EIS for management of noxious weeds in the Carson and Santa Fe National Forests is in the comment phase at the time this report was finalized.

6.7.2 Insect infestations. The monitoring plan calls for a survey of *Ips* insects in May/June after thinning. Beginning in spring 2003, high *Ips* mortality has been observed among the piñons on the north side of the Santa Fe River, related to the widespread regional beetle attack in piñon woodlands. The USFS Regional Forest Entomologist's report quoted in Section

1.1 also notes *Ips*-caused mortality among Ponderosa and Southwestern white pines in treatment areas, which may have been exacerbated by the presence of slash, attracting beetles to the area. On a positive note, overall mortality has been less than 2%; and there appears to be significant grass recovery under dead piñons in some areas of the SFMWP.

6.8 Wildlife Habitat & Diversity

6.8.1 Key Wildlife Habitat Features. The monitoring plan calls for a baseline survey and annual inventory after treatment, for large snags, down logs, and hardwoods; also canopy cover in drainage bottoms. This data is included in the RMRS study described below.

6.8.2 Overstory and Understory Trees and Plants

Bob Harrill was contracted by SFWA to apply a modified version of the methodologies used by Rocky Mountain Research Station and the Martinez protocols in collecting vegetation data on the north side of the watershed in fall 2003. He has committed to deliver his report and raw data to SFWA, but these materials were unavailable at the time that the present report was finalized.

For the vegetation data collection effort on the south side of the Santa Fe River see Section 6.8.4 under "Multi-parameter monitoring".

6.8.3 Aquatic Insects and Fish. Abraham Franklin, NMED SWQB, reports: Fish were sampled at the same locations as water chemistry. Fish continued to be less abundant at the site above Nichols Reservoir (between the dams) than at the other two sites. Fish did reproduce at all three sites in 2003. Benthic macro-invertebrates were collected from all three sites on October 31, 2003. Summaries of macroinvertebrate and fish data for the years for which the field data has been analyzed are presented in Attachments C-6 and C-7.

6.8.4 Wildlife Populations: Biological Diversity. Rocky Mountain Research Station has completed two years of an assessment of the effects of fuels reduction treatments in the SFMWP on resident wildlife, and is engaged in the third year of the study in 2004. The following discussion is condensed from the full report, "Santa Fe Watershed Fuels Reduction Project Wildlife Monitoring Progress Report" (January 2004)[2]. It discusses the data collected on populations of resident birds (including owls), small mammals, and arthropods during the 2002 and 2003 field seasons. Data on the composition and structure of the vegetative cover has been collected since the inception of the study but remains to be analyzed.

Study Design: RMRS used a modified "Before-After, Control-Impact" (BACI) study design to allow a reasonable chance of detecting a change in wildlife population estimates in response to treatments. This method was chosen over other approaches for two reasons. First, there is a lack of replication of the treatments, and second, there is the inability to randomly assign treatments to randomly chosen plots. These two factors contribute to conditions that could add experimental error. The BACI design addresses both the lack of replication and the inability to randomize by collecting pretreatment data and also collecting data at untreated reference plots.

The study design involves testing for an effect of fuels reduction treatments through an analysis of the abundance of targeted wildlife species through time. The abundance of target species is estimated at the southern half of the SFMWP that is undergoing treatment (an area of some 3,000 acres to the south of the Santa Fe

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River), and also at three reference sites located between one and five miles from the treatment area. These distances are close enough for the reference areas to be similar to the treatment site in terms of elevation and habitat type, yet far enough away not to be affected by the treatments. Each reference area is approximately one square mile (640 acres) in size. Two reference sites are located off Hyde Park Road, one near the Chamisa Trail and the other in the vicinity of Black Canyon Campground. A third set of reference points was established along the Santa Fe River upstream of McClure Reservoir, but part of this area was subsequently thinned and is scheduled for prescribed burning. The use of this site's data is under review.

Two factors may lead to variability in wildlife response to fuels reduction treatments. First, there are different types of treatment being applied, and the treatments are being implemented in phases (see Section 4.2). The wildlife study team has no control over these decisions. Therefore, we do not stratify our sampling based on different types of treatment, but rather include in our data set a classification of sampling points as untreated, "chunked", thinned with slash-piles subsequently burned, or burned only. Our methods also allow us to measure the severity of fire experienced at a sampling location.

The second factor affecting variability of wildlife response is the variety of forest types within the Santa Fe Municipal Watershed, including Ponderosa pine - dominated stands, mixed-conifer stands, and riparian woodland. We have designed a systematic sampling approach to cover all three major habitat types. The Ponderosa pine habitat is the most extensive and is the main cover type in the upland areas (i.e., those areas outside riparian and drainage bottoms). We placed a grid of 64 sampling points on 400-meter spacing across this habitat type. The mixed-conifer habitats are predominant in the cooler drainage bottoms: This forest type is sampled at 15 points placed at 300-meter intervals along transects running through the major tributaries to the Santa Fe River at the treatment site. The riparian woodland habitats are also linear in nature, and points were placed at 300-meter intervals along transects paralleling the Santa Fe River between McClure and Nichols Reservoirs (treatment area, 8 points). The total number of sampling points within the treatment area comes to 87. Within the reference areas, there are a total of 35 points. There are 8 riparian sampling sites upstream of McClure Reservoir, and 9 upland points at each reference site, established using the same basic arrangement of points in Ponderosa pine and mixed-conifer habitats as was used in the treatment area.

For full descriptions of sampling methodology and data management protocols for birds, mammals, arthropods, plant community composition and habitat structure, the reader is referred to the main report cited in the first paragraph of this section. In view of its connection with monitoring of soil erosion potential, a summary of the data collected on vegetative parameters is tabulated below, presenting a timeline for activity in the RMRS study to date and projected through completion of the study.

HABITAT VARIABLE	SAMPLING METHOD
Tree density	Tally in 11.3 m plot
Shrub density	Tally in 5 m plot
Basal area	DBH measures in 11.3 m plot
Canopy and ground cover	Ocular tube points on 11.3 m transects
Canopy height	Min, max and mean
Fuel loads	Fuels intercept on transects
Litter depths	At points on 5 m transects
Herbaceous understory	Point intercepts on 11.3 m transects
Vertical	From four corners of 11.3

heterogeneity	m transects
Fire severity	Scorch and intensity estimates on 11.3 m plot

PERIOD	ACTIVITY
June – September 2001	Established permanent study points
May – September 2002	Collected baseline data on all plots and transects
October 2002	First treatments begun with trees thinned in selected areas
May – September 2003	Collect data on all plots and transects, both thinned and untreated
October 2003	Slash piles burned following thinning (treatments now complete in 800 acres)
May – September 2004	First collection of data following completion of treatments
May – September 2005	Collect data on all plots (2 years post-treatment)
May – September 2006	Collect data on all plots (3 years post-treatment)
May – September 2008	Monitoring of a sub-sample of points
May – September 2010	Monitoring of a sub-sample of points

***Results and Discussion*:** For tables and graphs summarizing the data collected in the RMRS study to date (including lists of fauna species observed in the study area), please refer to Attachment E.

***Birds*:** Overall, we observed fewer birds in 2003 than in the previous field season. Some species had declines between the two seasons, and some were observed in greater abundance. We expect that the differences in populations between the two years could be due to normal fluctuations related to abiotic events and/or observer bias/inexperience. The previous year, 2002, was very dry in the spring and summer. Our field season began with forest closure due to severe fire danger. We had no significant rain events until late August. The 2003 field season was very different. We began the field season with water flowing in all intermittent streams. In addition, we had several small rain events in the spring. Although we had a dry summer, the fall again brought significant rains in the latter part of August and early September.

The previous years' abiotic factors (rain/snow) do affect brood success and survivability of immature post-nesting animals due to scarce food supplies: This could explain the observation that fewer birds overall were observed in 2003 than in 2002. In the future, as we collect more data, we will be able to increase our sample size in terms of years, enabling use of statistical analyses to remove the effect of abiotic factors from our observations.

Species diversity (the number of species) in both the treatment and reference areas increased between the first field season and the 2003 field season. However, the relationship of species diversity between the treatment and reference areas remained the same, with higher diversity in the reference areas for both years. Since treatments were being implemented as the RMRS study was being performed, we can assume that the data were somewhat biased by the treatment applications (i.e., disruption of mating, nesting or feeding activities due to the presence of humans with chain saws).

Some changes were observed in species richness (the number of species observed between the areas and across the years). In both 2002 and 2003, the reference area species richness remained at 56 species. In the treatment areas, we saw a small decrease from 50 species in 2002 to 48 species in 2003.

To summarize: The reference areas were higher than the treatment areas in avian species richness and diversity for both 2002 and 2003. Although there was an overall increase in diversity from 2002 to 2003 for the treatment areas, the increase was not proportionate to the previous year's study—it is less by a factor of 0.04. This could be considered an effect of the treatment applications. In addition, we saw a small decrease in species richness for the treatment areas, which may also be due to treatment activity. We must keep in mind that we observed fewer individuals in 2003 in both areas. Therefore, abiotic factors cannot be eliminated as a contributing factor in any estimated declines.

Along with the overall decline in number of birds from 2002 to 2003, we also saw a small apparent decline in the density of all birds over time. The apparent change in the reference area density is very small, but the change in the treatment areas appears to indicate a slight trend toward a decline. The standard error bars do overlap; therefore, we cannot presently declare that we have observed any change in density between treatment and reference areas across years.

From our density estimates, we selected several bird species representing different habitat requirements. We selected these from the 14 bird species (Attachment E-2) that were observed in enough abundance for the Distance program to perform accurate calculations to estimate densities. The selected bird species (Attachment E-9) show mixed results, illustrating how misleading it can be to use a single species as a reference to the response of all wildlife. The data seem to indicate that any declines or increases in any one species do not necessarily reflect the overall effect of the treatments on all bird species. As one species is benefited by changes in habitat, another might be adversely affected, and another remains unchanged. Each species responds to changes in their habitat according to its own life history. In addition, these changes in habitat are not necessarily due to human interference, but can be due to normal yearly fluctuations due to yearly abiotic fluctuations. While mountain chickadee declined in both observation areas, warbling vireo exhibited a dramatic increase in density. Most species did not change significantly either over time or between the treatment areas and the reference areas, when you allow for standard error. Some species exhibit a puzzling change: significant decreases in yellow-rumped warbler density in the treatment areas, but a significant increase, proportionally, in pygmy nuthatch density in the same area in the two-year observation period. Unless there is a reason to target specific bird species, combining all bird species observed for estimates of density seems to be a better method of calculating the effect of the thinning on birds.

Another possible cause of the mixed results with individual species is observer bias. RMRS uses seasonal technicians to conduct the point counts. Biotechnical crew members change from one year to the next. The differences in observer variability each year in acuity of physical senses, ambition, and avian identification skill levels may contribute to variation in number of detections. Some "biotechs" might be more skilled at identifying a particular species than other technicians. This could skew data for that entire field season for one or more species. More data over more time will help to even out this bias.

Another possibility, with more years of data, would be to separate the birds into guilds. We could evaluate data by grouping species into nesting guilds, all cavity nesters for example, to explore the possibility that fuels removal has an effect on cavity nesting birds.

Owls were surveyed during both the 2002 and 2003 field season. During the 2002 surveys, the owl call playback equipment was marginal and the surveys were only carried out for one

round. For that reason only data collected in 2003 are presented in this report (Table E-3). For all owls combined, we see that the reference area had more numerous responses observed than the treatment areas. The reference areas had 58% more owl responses observed than the treatment areas.

As an ancillary effort, we attempted to locate, observe, and record the fate of bird nesting for both years (Attachment E-4). We found more nests in 2003 than in 2002, and the 2003 nests had a higher rate of nest success. Nevertheless, the small number of nests observed is not significant enough for assessing the effect of the treatments or the treatment applications. We will continue to attempt to find nests and observe their fate. Hopefully, in subsequent years we will have a large enough database to use nesting success as a component when assessing treatment effects.

Taking into account the change in species diversity, species richness, apparent decline in density of all birds, and the overall decline in number of birds observed, we suggest that birds in the treatment areas in 2003 exhibited some response to a treatment application. However, this apparent effect is so small that we cannot separate it from possible background abiotic conditional effects with 95% certainty. Perhaps another year of data will help to strengthen the magnitude of any effect of fuels removal, if any exist.

Mammals: Mammalian species diversity increased overall over time (Attachment E-10). Unlike the birds surveyed for this study, mammalian species diversity in the treatment areas actually increased at a higher proportional rate than in the reference areas.

The number of mammalian species (i.e., species richness) increased from 2002 to 2003 for both area trap webs (Attachment E-5). However, the webs in the reference areas exhibited higher richness than the treatment areas. The mammalian transects also had higher richness overall from one year to the next. However, the transects in reference areas exhibited a small decrease in richness while the treatment areas remained the same.

As in 2002, the only mammal species trapped with a high enough frequency for use with the "Distance" density program were deer mice (*Peromyscus maniculatus*) (Attachment E-11). Deer mice exhibited an overall increase in the density estimate over time, but with no apparent difference between the treatment and reference areas.

Relative abundance (number of individuals observed) appears to be the best method to assess all mammals observed across time and between treatment and reference areas (Attachment E-5). When assessing number of web individuals per trap-night (ind./trap), we observed that there was an overall increase from 2002 to 2003 for both treatment areas and reference areas. In 2003, we had greater abundance in the reference area in contrast to 2002, when the greater abundance was in the treatment areas. We found the same increase in abundance overall on the transects, but found that in both years the reference areas display higher mammalian abundance than the treatment areas.

Looking at the overall picture of species diversity, species richness, deer mouse density, and relative abundance, we find that we have mixed results. It is likely that area-specific abiotic factors are responsible for these results. In addition, since no treatments were initiated on the riparian areas prior to or during data collection, and only one web was impacted by the treatments, we do not have enough treatment data to indicate any effect of the application of the treatments. In addition, small mammals that were likely to have been affected by treatment activities have small home ranges, which were not likely to have

been affected by treatments unless the proximity of the treatments or treatment activities were nearby. It is likely that by next year more of the webs and transects will be affected more directly. We hope to be able to obtain better data on the effect of the treatments on these taxa with another year's data.

Arthropods: For the purpose of this report, arthropods are identified to Family only, not to species. Since it is not possible to compare the species diversity or species richness of arthropods over time and between treatment and reference areas, we used a measure of relative abundance of individuals per vegetation plot (ind./point; Attachment E-6). There has been an overall increase in ind./point in both treatment and reference areas over the course of the study, with reference areas having more ind./point than the treatment areas for both years. Since there were no treatments in 2002 and the increase (2002/2003) in the treatment areas (0.90) is somewhat proportional to the reference increase (0.88), we cannot infer any effect from the treatments or treatment activities in 2003.

There was an apparent increase in Orders and Families from 2002 to 2003, as shown in Attachment E-7. However, the difference is not likely due to any effect of treatments but more likely due to an increase in the experience and knowledge of the biotech that identified the arthropods in both years. We hope that the same technician will be available again next year, and we can look at the number of families to help discern effects of subsequent treatments on arthropods.

Conclusions of the RMRS Study: Birds, mammals, and arthropods all exhibited some mixed results. The results do not support the hypothesis either that the treatments themselves have an effect on the wildlife populations, or that the activity of applying the treatments has an effect on the wildlife population. This is by no means conclusive for the overall study but only for this year. It is possible that an effect of the treatments could be evident in next year's data.

Beaver Dam Survey. The EIS monitoring plan calls for an inventory of active beaver dams prior to treatment and every spring or summer following treatments. Mary Orr, SFNF Wildlife Biologist, has been carrying out these surveys.

The baseline survey took place November 9, 2001, and identified 18 to 20 active beaver dams, one active lodge and one or two active bank holes in the Santa Fe River downstream of McClure Reservoir. A second survey was conducted on August 6, 2003 between the upstream end of Nichols Reservoir and the base of McClure Dam. The following observations were made:

A lodge and several dams upstream of Nichols Reservoir had been abandoned due to the lowered reservoir level (all of these structures were on dry land), and a number of other old dams and lodges were abandoned. However, new dam-building activity was also observed. Beaver had felled nearly all the cottonwoods in two large flooded zones, and are venturing further from the river channel in search of additional food sources.

Orr also observed that the archaeological study of the SFMW noted a reference to the presence of beaver in the SFMW in the 1930s.

7.0 Conclusions and Recommendations

The Santa Fe Municipal Watershed Project has demonstrated a number of things to date:

1. The benefits of a flexible reading of the EIS to allow adoption of a technology that was unknown to the framers of the EIS. This has resulted in a treatment that has been implemented far more rapidly than anticipated, and on more of

the landscape than previously thought possible.

2. The necessity of consistent observation and monitoring of the forest, and adjusting the approach to treatment as indicated by such observations (i.e., adaptive management). Examples include: incorporating protection of Southwestern white pine into the treatment prescriptions (Section 1.1) and locating alternatives to the pile-and-burn model following the demo plot experience (see Section 6.3).

3. The importance of community involvement to maintain pressure for project implementation (including monitoring), including the development of an effective model for community involvement that consists of:
   - Conducting monitoring to understand the effects of treatments;
   - Independent scientific review to verify that the data collection effort is conducted professionally, and to assist in interpretation of results and recommendations for adaptive management (the TAG process);
   - Opportunities for the public to interact with those conducting the monitoring and implementation of treatments, at TAG meetings and on watershed hikes.

4. The importance of going through channels unavailable to the Forest Service to obtain funding for implementation, as illustrated by SFWA and the City approaching the congressional delegation for a direct appropriation for the project.

5. The benefits of encouraging our political representatives to serves as advocates by keeping them informed about the project. If it were not for the earmarked appropriations for the SFMWP obtained by New Mexico's senators, the Forest Service budget process would have restricted implementation to a few hundred acres a year at best.

6. The need for a coordinator for the monitoring, managing the TAG process and community outreach elements of the project.

7. The fact that goodwill and volunteerism can accomplish only so much in the sphere of long-term monitoring. Ultimately the work of collecting, interpreting, and reporting on the data and ensuring that it is used in adaptive management, must be funded or another motivation given, such as publication of results in peer review journals.

Santa Fe National Forest
Espanola Ranger District
Santa Fe Watershed Thinning Project

JUAN DE GABALDON GRANT

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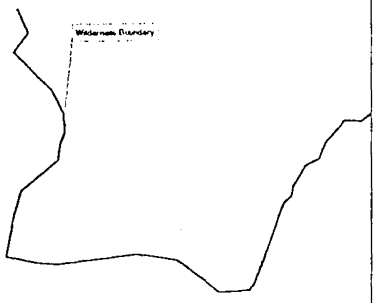

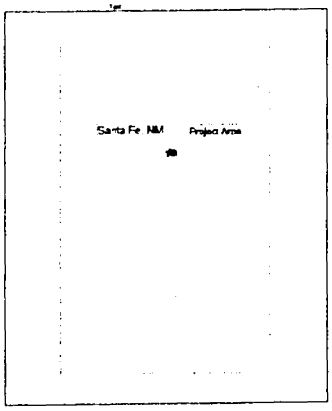

LEGEND

3058 Acres completed to date

Estimate 3100 Acres remain to be treated in Phase 4

Purple shaded areas are thinned units

Grayed areas are untreated acres

0 0.2 0.4 0.8 Miles

- wilderness boundary
- Project Boundary - phase 4
- Project Boundary - phase 3
- Project Boundary - phase 2
- Project Boundary - phase 1
- treated pared basin
- untreated pared basin

09/15/2004 D. Isackson

ATTACHMENT A:

Members of Technical Advisory Group (TAG)

TAG Process Participants

Participants at 4/22/04 TAG Meeting

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April 2004

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Note: the subject areas listed in bold are taken from the *Environmental Impact Statement for the Santa Fe Municipal Watershed Project, Appendix B: Project Monitoring Plan.* The assignment of TAG members to a particular subject area is somewhat arbitrary, since the expertise of many TAG members embraces more than one subject area; however, the objective is to ensure that the knowledge base of the TAG covers all of the parameters identified in the Project Monitoring Plan.

TAG Process Participants

City of Santa Fe:

Borchert, Claudia – Water Division
Nolde, Shelley – Fire Department
Williams, Neil – Contractor, Paired Basin study

Forest Trust:

Schumann, Martha – included SFMWP in review of forest restoration projects

NM Environment Department:

Franklin, Abe – 319 grant Project Manager; water quality/riparian health monitoring in SFMWP

Rocky Mountain Research Station:

Leonard, Billy – Field Supervisor, Ecosystem Monitoring Project
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Santa Fe National Forest:

Alter, George – Silviculturist
Armstrong, Bill – Project Manager, comparable project in Los Alamos
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Garcia, Maria – Deputy Ranger, Española District
Hurlocker, Sandy – NEPA Specialist
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Johnston, Tom – SFNF Assistant Fire & Fuels Managing Officer (AFFMO)
Miera, John – Espanola District Ranger
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Peterson, Don – Thinning Contractor

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Harrill, Bob – Contractor, vegetation monitoring
Johnston, Janine – Acting Executive Director
Tharnstrom, Steve – Archival photo researcher; photo point monitoring spec.

USEPA:

Herfel, Tim – 319 Program Manager, Region VI

USGS:

Hogan, John – representative from comparable project in Los Alamos

Technical Advisory Group (TAG) to the Santa Fe Municipal Watershed Project Meeting April 22nd, 2004

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Santa Fe Watershed Association
Technical Advisory Group White Paper:

Exercise in Adaptive Management: Should thinning prescriptions be modified to avoid over-thinning, given the likelihood that there will be post-thinning tree mortality caused by beetles or other vectors?

Problem: Tree mortality caused by bark beetles and other vectors has been observed in the Santa Fe Municipal Watershed. Are the thinning activities influencing the activity of beetles and other disease-causing organisms? Should we recommend changes in the thinning activities to prevent the creation of excessively open patches in the forest? The Forest Service is particularly concerned with the population of Southwestern white pine (*Pinus strobiformis*) in the watershed. Most white pine in the state is found in the south where populations are being damaged by white pine blister rust. They would like to protect this disease-free population in the watershed.

Background information: Bark beetle populations are present in the watershed. There has been some mortality in ponderosa pine and apparently in Southwestern white pine. The majority of mortality has been in piñon pine (piñon *Ips*, which do not attack other pines). The FS Regional entomologist, Debra Allen-Reid does not think that the potential for ponderosa and white pine mortality is as high in the watershed as elsewhere in the state, but there are no guarantees.

Thinning activities can have multiple effects on beetle-induced mortality. Thinning activities can release aromatic compounds that attract beetles. This is more of a problem in the warmer months when the beetles are active. Leaving piles of slash is more likely to attract and harbor beetles than is tree mulch, which dries out quickly and can't be used as a food source. Thinning should reduce competition for resources and leave the standing trees less susceptible to beetle attack, particularly if they make it through the first year. This has been a wet spring, trees may be healthier than in past years.

What are the consequences of post-thinning mortality? We are currently thinning to between 40-80 trees per acre depending on location. Would it be a problem if post-thinning mortality reduced these densities in some areas? Beneficial aspects of tree mortality include creation of snags for wildlife habitat and creation of openings or more open conditions that promote herbaceous plant growth and further reduce fire hazard. Negative aspects might include high bark beetle mortality in the Southwestern white pine, if our thinning activities aggravate the problem.

Potential Options:

1. In applying the fuels reduction prescription, retain Southwestern white pine wherever possible.
2. Stop all thinning while beetles are active.
3. Stop felling/piling activity, utilizing machine mastication only.
4. Thin to higher tree densities (80-100 trees/acre?) in anticipation of beetle kill.
5. No change in plans.

Consequences:

1. Should be no negative consequences, easy to implement, and in fact is the practice currently in place.
2. In this area, beetles are active between approximately March to October, depending on temperatures. Obviously, we would be likely to fall behind schedule in thinning to reduce the danger of crown fire, and would probably have contract issues to deal with if we were stop all thinning during that season. Also, there is no guarantee that this option will protect against beetle attack.
3. This option would reduce thinning productivity and again result in contract issues. According to the entomologists, it would be less likely to attract beetles, which could reduce subsequent tree mortality.
4. This option would maintain or increase thinning productivity. Subsequent beetle kill could bring trees down to target densities. If there is little beetle kill we may have to go back in for follow-up treatments.
5. This option would also maintain current thinning productivity and maximum treatment flexibility. It may also be the riskiest option with respect to potential beetle-induced mortality. On the other hand, post-treatment mortality could create greater habitat heterogeneity including grassy forest openings which were once common in the Sangre de Cristos and are now increasingly rare.

Recommendations:

✓ Apply Options 1 and 5 – proceed with current thinning prescription, and continue to protect Southwestern white pine wherever possible.

✓ Request assistance from the Regional Office in monitoring tree mortality caused by insects and other vectors.

ATTACHMENT C:

Data Collected by New Mexico Environment Department in Santa Fe River within Santa Fe Municipal Watershed Project

C-1: Water Chemistry – Analyte List
C-2: Water Chemistry – Analytes Detected
C-3: Total Dissolved Solids (TDS) Graphs

C-4: Water Temperature

C-5: Geomorphology

C-6: Macroinvertebrates

C-7: Fish

C-1: WATER CHEMISTRY – ANALYTE LIST

Analytes in SFMWP Water Quality Study of Santa Fe River

Analytical suite	Analyte	Detected?	Analytical suite	Analyte	Detected?
Bacteria (E. coli)	E. Coli	✔	Metals (dissolved)	Aluminum	✔
	Fecals	✔		Antimony	
Cyanides	Cyanide, weak acid dissociable			Arsenic	
Ions	Alkalinity	✔		Barium	
	Bicarbonate	✔		Beryllium	
	Calcium	✔		Boron	
	Carbonate	✔		Cadmium	
	Chloride			Calcium	✔
	Fluoride	✔		Chromium	✔
	Hardness	✔		Cobalt	
	Hardness (Ca & Mg)	✔		Copper	
	Magnesium	✔		Iron	✔
	Potassium	✔		Lead	✔
	Sodium	✔		Magnesium	✔
	Sulfate	✔		Manganese	✔
	Total Dissolved Solids	✔		Molybdenum	
Nutrients (total)	Ammonia	✔		Nickel	
	Nitrate+ Nitrite (N)			Selenium	✔
	Phosphorous, Total	✔		Silicon	✔
	TOC	✔		Silver	
	Total Kjehldal Nitrogen	✔		Strontium	
	Total Organic Carbon	✔		Thallium	
				Tin	
Metals (Hg/Se): suite listed to right plus –	Mercury			Uranium	✔
Metals (total): as above–	Mercury			Vanadium	✔
				Zinc	✔

C-1: WATER CHEMISTRY – ANALYTE LIST continued

SFMWP Water Quality Study continued: Organics

Analytical suite	Analyte	Detected?	Analyte	Detected?
Organics (semi-volatiles)	1,2,4-Trichlorobenzene		Arochlor-1242/1016	
	1,2-Dichlorobenzene		Arochlor-1248	
	1,3-Dichlorobenzene		Arochlor-1260	
	1,4-Dichlorobenzene		Atrazine	
	2,4-Dinitrotoluene		Azobenzene	
	2,6-Dinitrotoluene		Benzo(a)anthracene	
	2-Chloronaphthalene		Benzo(a)pyrene	
	2-Methylnaphthalene		Benzo(b)fluoranthene	
	2-Nitroaniline		Benzo(g,h,I,)perylene	
	3,3'-Dichlorobenzidine		Benzo(k)fluoranthene	
	3-Nitroaniline		beta-BHC	
	4,4'-DDD		bis(2-Chloroethoxy)methane	
	4,4'-DDE		bis(2-Chloroethyl)ether	
	4,4'-DDT		bis(2-Chloroisopropyl)ether	
	4-Bromophenyl Phenyl Ether		bis(2-Ethylhexyl)phthalate	
	4-Chloroaniline		Butyl Benzyl Phthalate	
	4-Chlorophenyl Phenyl Ether		Carbazole	
	4-Nitroaniline		Chrysene	
	Acenaphthene		cis-Chlordane	
	Alachlor		delta-BHC	
	Aldrin		Dibenz(a,h)anthracene	
	alpha-BHC		Dibenzofuran	
	alpha-Chlordane		Dieldrin	
	Anthracene		Diethylphthalate	
	Arochlor-1221		Dimethylphthalate	
	Arochlor-1232		Di-n-butyl Phthalate	

C-1: WATER CHEMISTRY – ANALYTE LIST continued

SFMWP Water Quality Study continued: Organics & Radionuclides

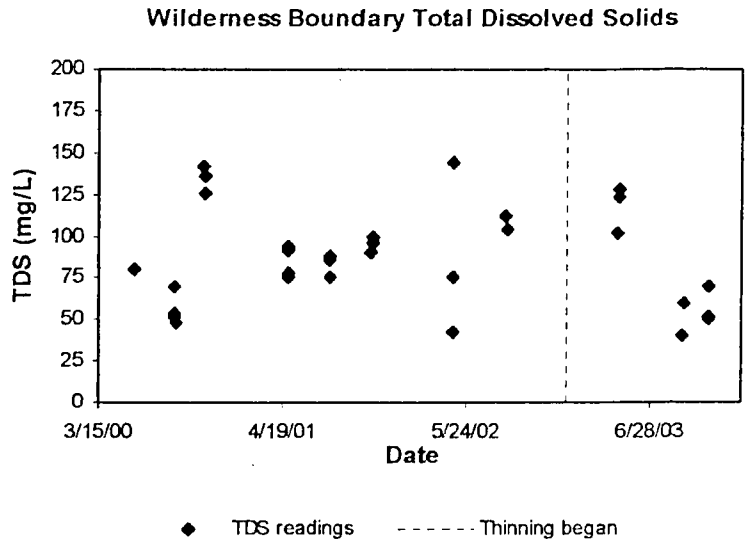
Analyte	Detected?	Analytical suite	Analyte	Detected?
Di-n-octyl phthalate		Radionuclides	Actinium-228	
Endosulfan I			Americium-241 (alpha spec)	✔
Endosulfan II			Antimony-125	
Endosulfan sulfate			Bismuth-212	
Endrin			Bismuth-214	
Endrin aldehyde			Cesium-134	
Endrin ketone			Cesium-137	
Fluoranthene			Cobalt-60	
Fluorene			Europium-152	
gamma-Chlordane			Europium-154	
Heptachlor			Gross alpha (Am-241 ref.)	✔
Heptachlor epoxide			Gross alpha (U-nat ref.)	✔
Hexachlorobenzene			Gross beta (Cs-137 ref.)	✔
Hexachlorobutadiene			Gross beta (Sr/Y-90 ref.)	✔
Hexachlorocyclopentadiene			Lead-210	
Hexachloroethane			Lead-214	
Indeno(1,2,3-cd) pyrene			Manganese-54	
Isophorone			Plutonium-(239+240)	
Lindane (y-BHC)			Plutonium-238	
Methoxychlor			Potassium-40	
Naphthalene			Radium-226	✔
Nitrobenzene			Radium-228	✔
N-nitroso-di-n-proplamine			Thallium-208	
N-nitrosodiphenylamine			Thorium-234	
Phenanthrene			Uranium-234	✔
Pyrene			Uranium-235	
Simazine			Uranium-238	✔
Toxaphene			Zinc-65	
trans-Chlordane				

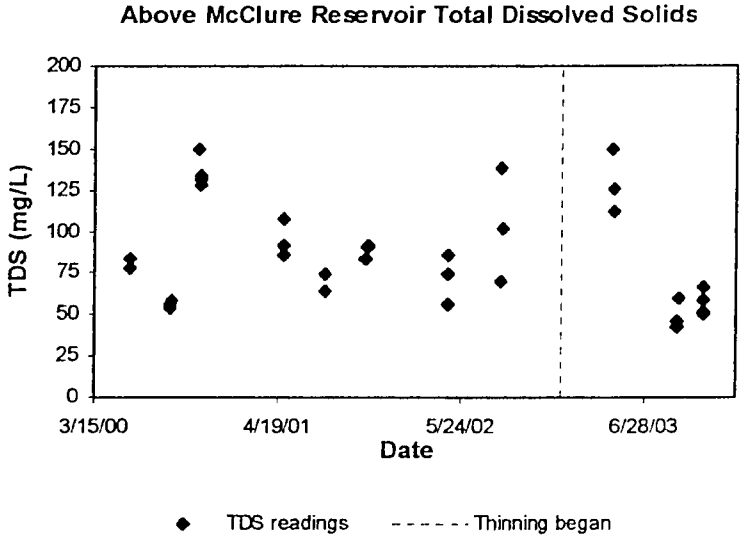
C-2: WATER CHEMISTRY -- Analytes Detected

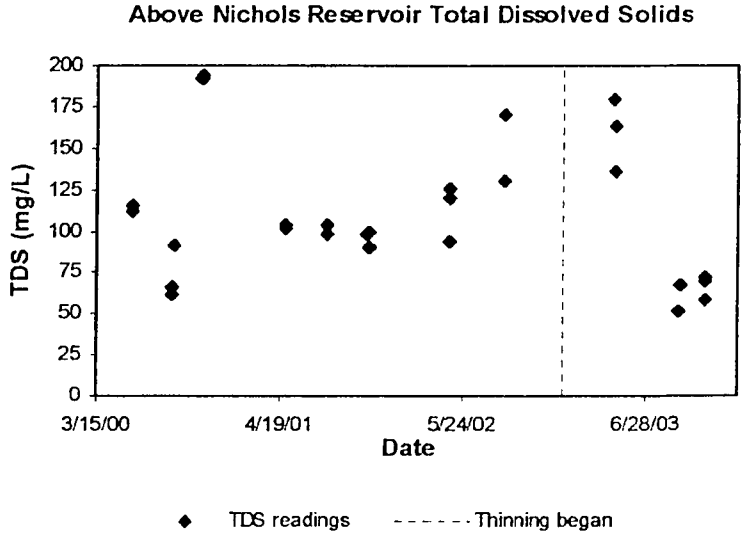
Analyte	Highest Detected Level	Units	Standard	Source
Aluminum	**1.5**	**mg/L**	**0.05 to 0.2**	**secondary standard**
Chromium	0.004	"	0.1	primary standard
Iron	**1.1**	**"**	**0.3**	**secondary standard**
Magnesium	8	"	NA	
Manganese	0.05	"	0.05	secondary standard
Silicon	9.6	"	NA	
Uranium	0.003	"	0.02	EPA MCL
Vanadium	**0.1**	**"**	**0.02**	**EPA Health Advisory**
Zinc	0.04	"	5	secondary standard
Americium-241:				
alpha	0.03	pCi/L	]	
gamma	5	"		
Gross alpha:				
Americium-241 reference	3.3	pCi/L	] 15, combined	
U-natural reference	4.8	"	] "alpha emitters"	EPA MCL
Gross beta:				
Cesium-137 reference	2.5	pCi/L	) 4 millirems	EPA MCL - note
Sr/Y-90 reference	2.4	"	) combined	different units
Manganese-54	3.8	"		
Radium-226	0.13	"	} 5, combined	EPA MCL
Radium-228	0.9	"	} radium 226+228	
Uranium-234	0.54	"		
Uranium-235	0.04	"		
Uranium-238	0.38	"		
Zinc-65	23	"		

Notes: "primary" and "secondary" standards refer to National Drinking Water Regulations. EPA Health Advisory standards are not enforceable standards; MCLs (Maximum Contaminant Levels) are.

C-3: Total Dissolved Solids

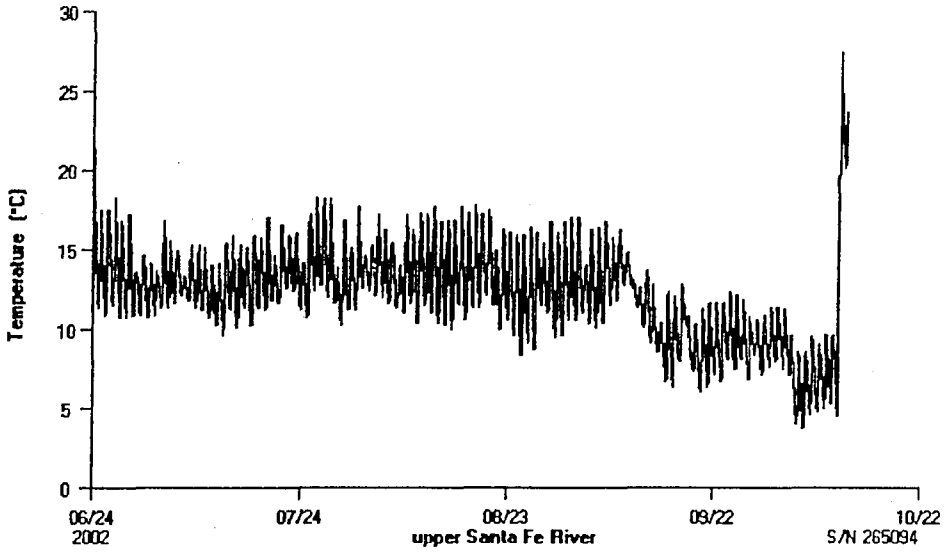


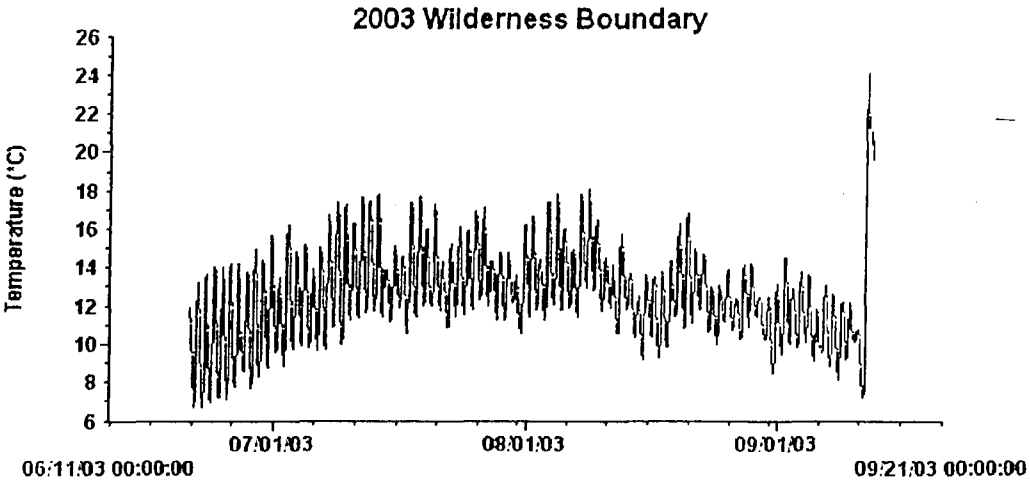


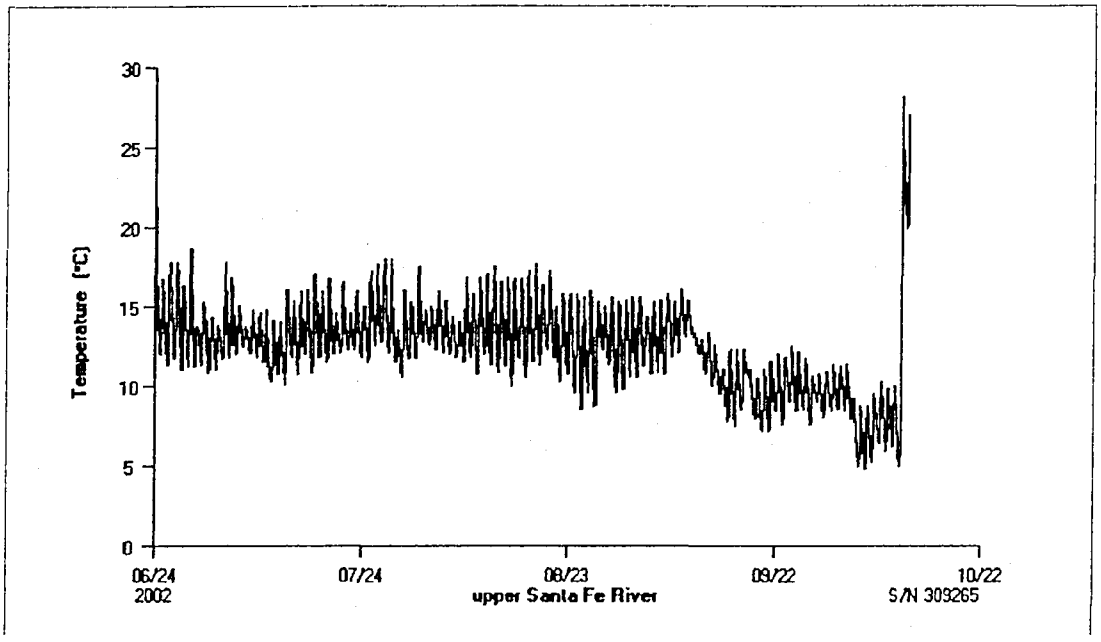


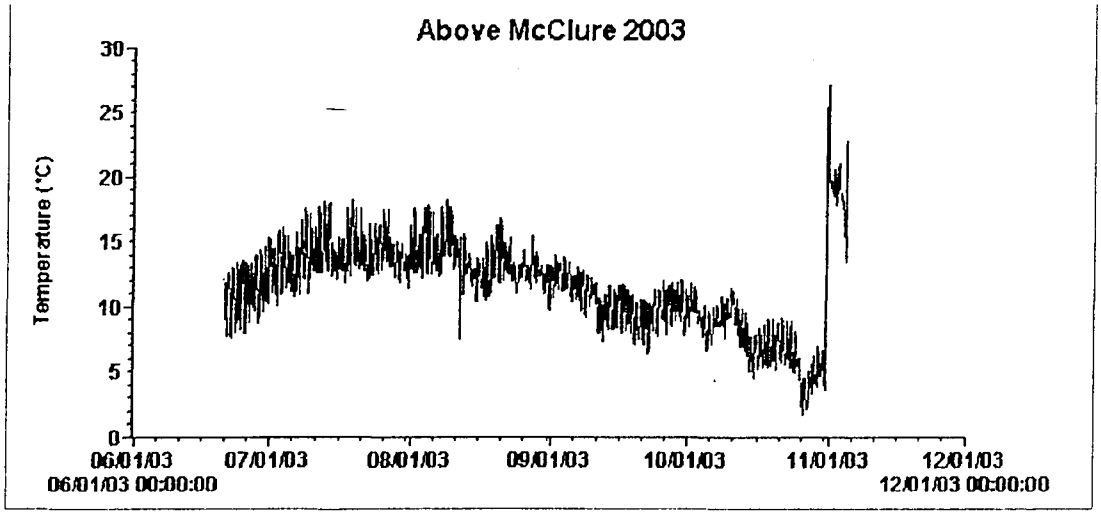
C-4: Water Temperature, Santa Fe River atWilderness Boundary, 2002-2003

Note: "spike" at end of each graph due to delay in turning off thermograph after removing from water.

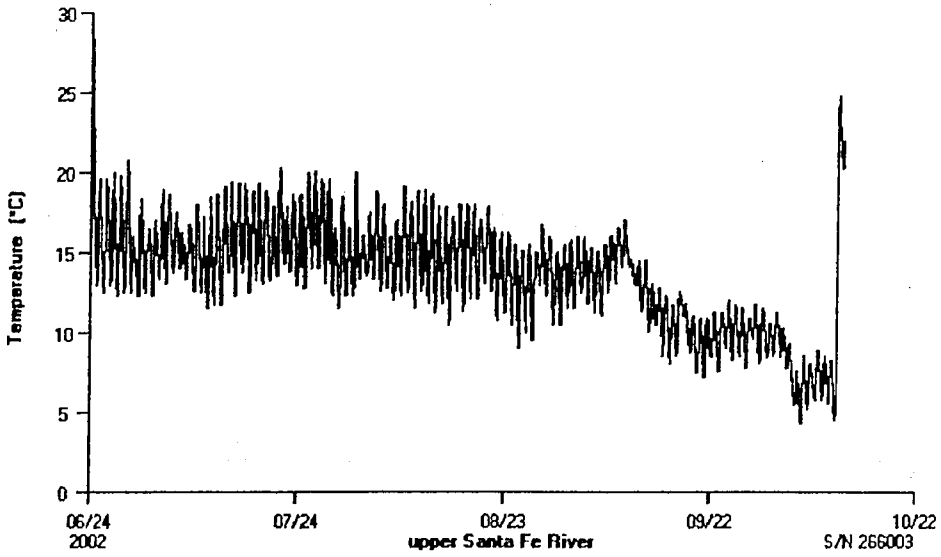


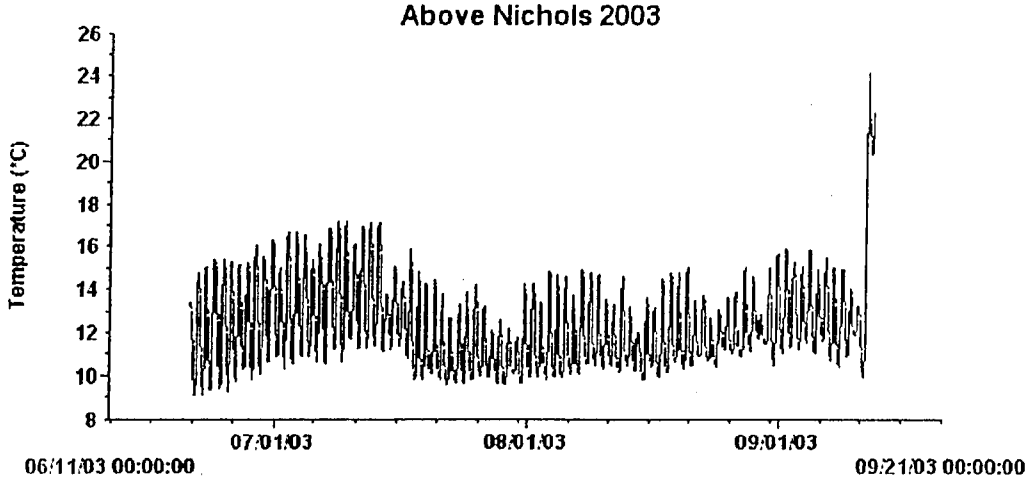



Temperature (°C)
30
25
20
15
10
5
0
06/24
2002
07/24
08/23
09/22
10/22
upper Santa Fe River
S/N 309265

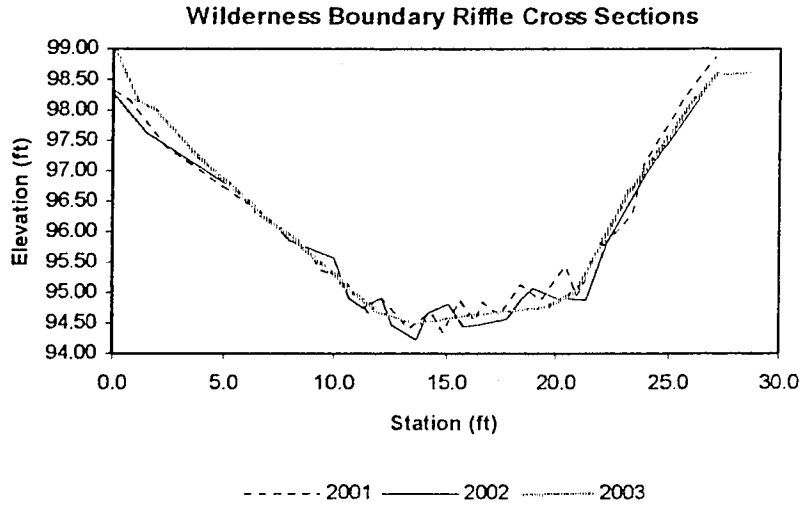

Above McClure 2003
Temperature (°C)
30
25
20
15
10
5
0
06/01/03
06/01/03 00:00:00
07/01/03
08/01/03
09/01/03
10/01/03
11/01/03
12/01/03
12/01/03 00:00:00

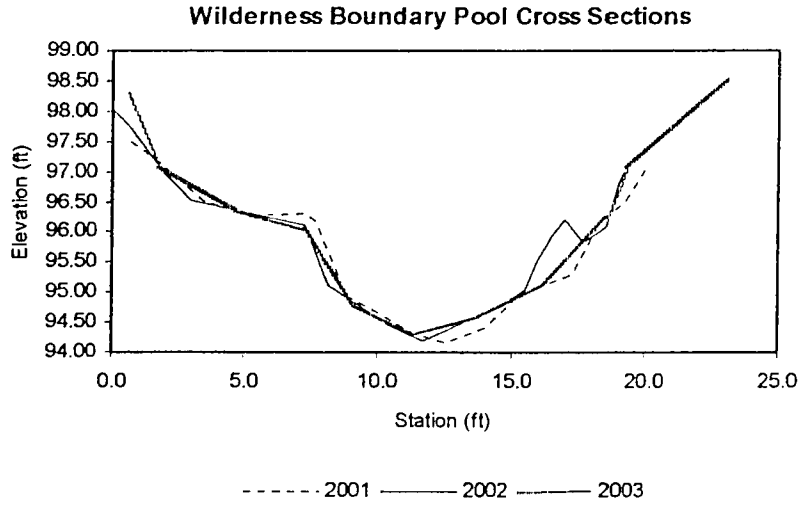
C-4 continued: Water Temperature, Santa Fe River Above Nichols Reservoir, 2002-2003

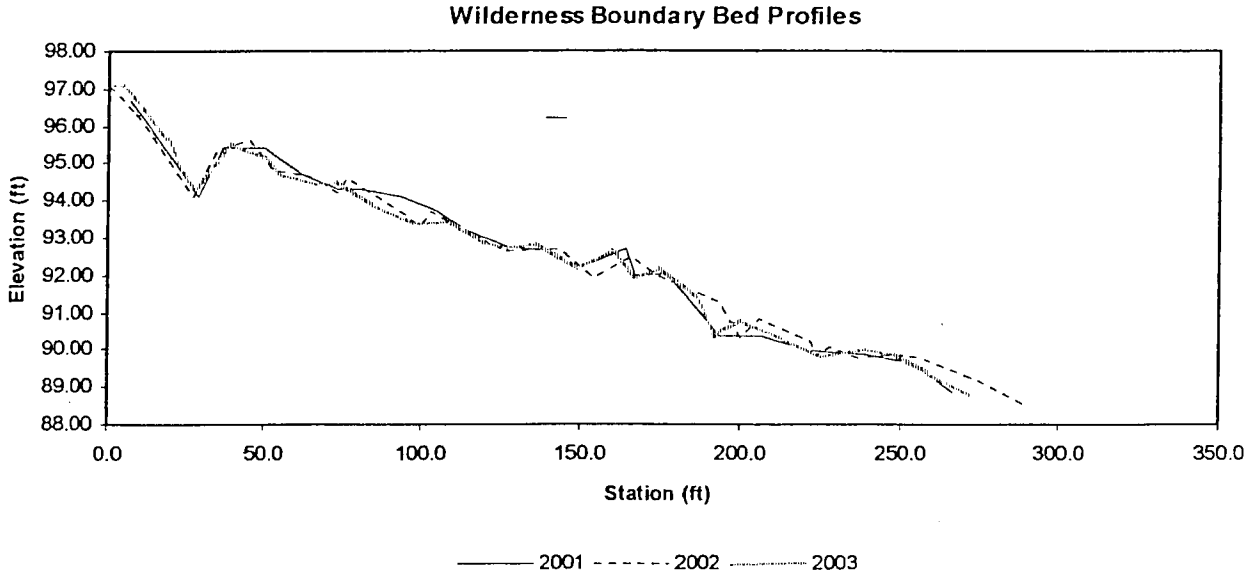




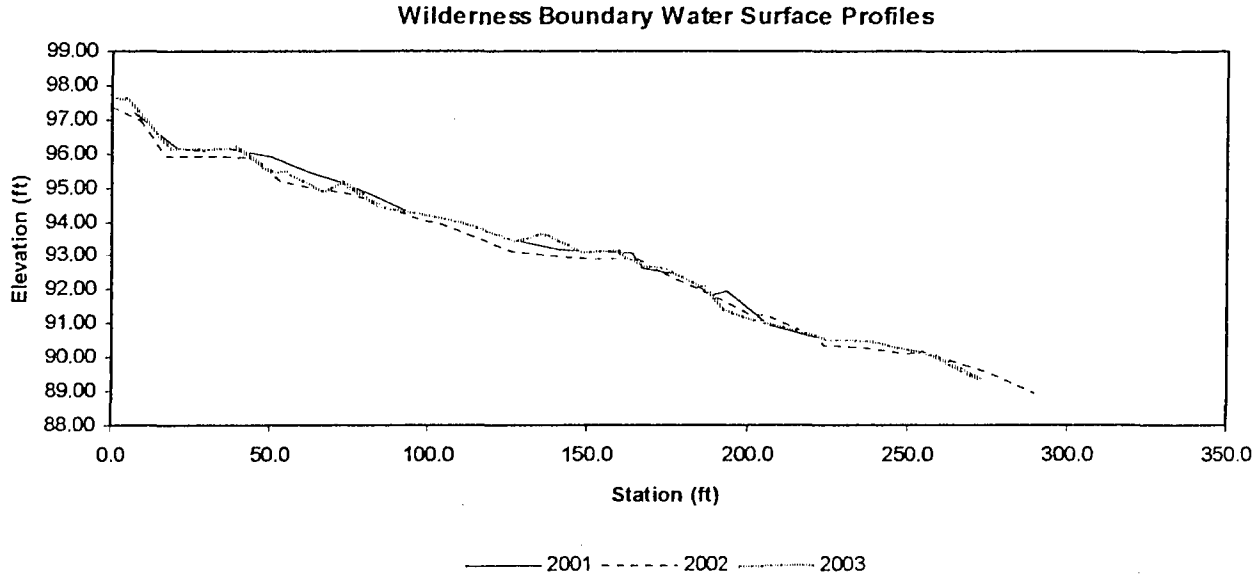
C-5: Geomorphology of Santa Fe River at Wilderness Boundary

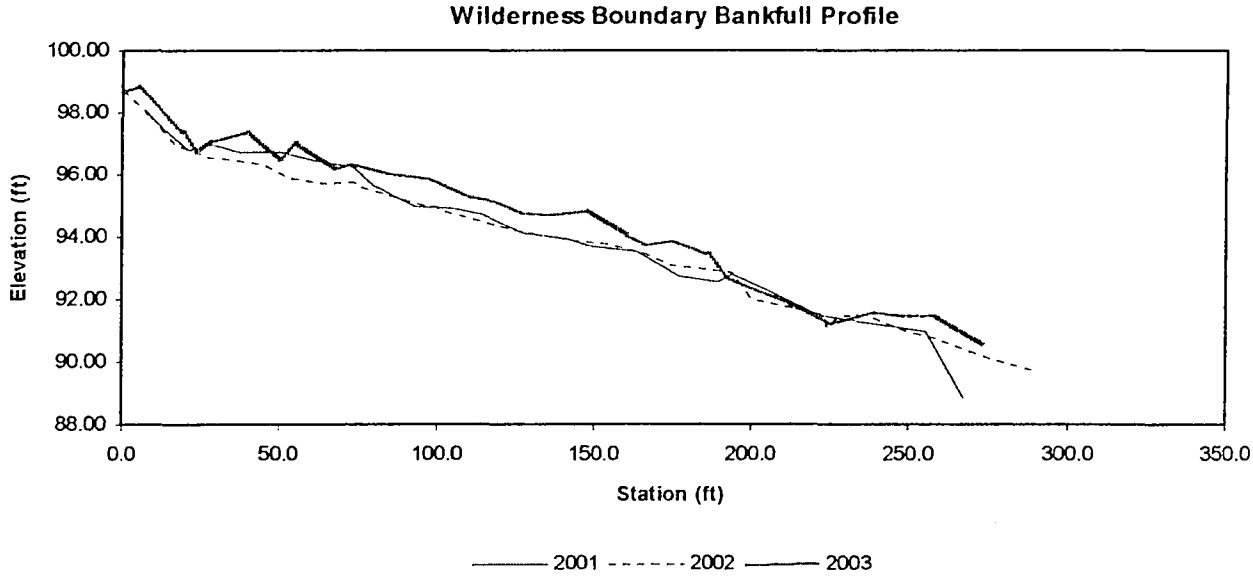


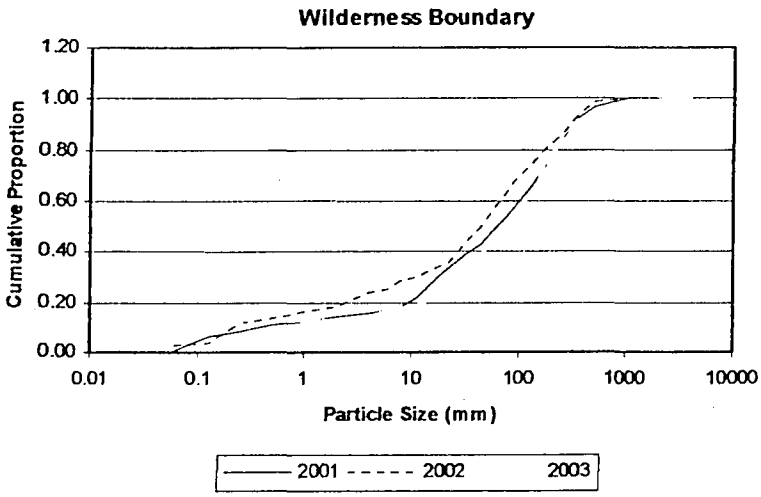


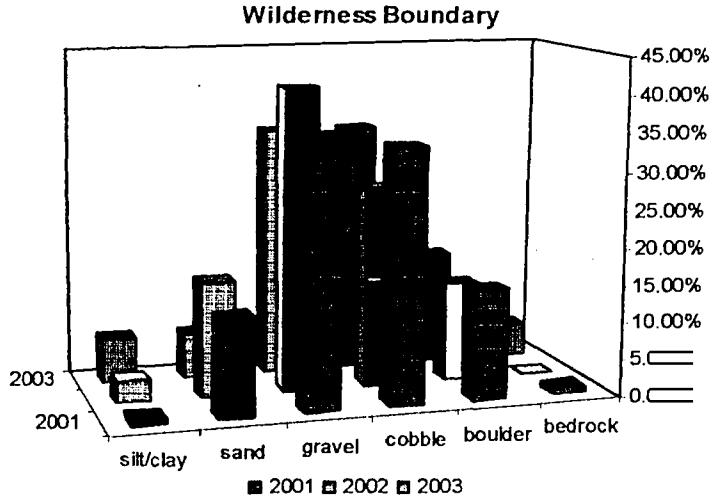


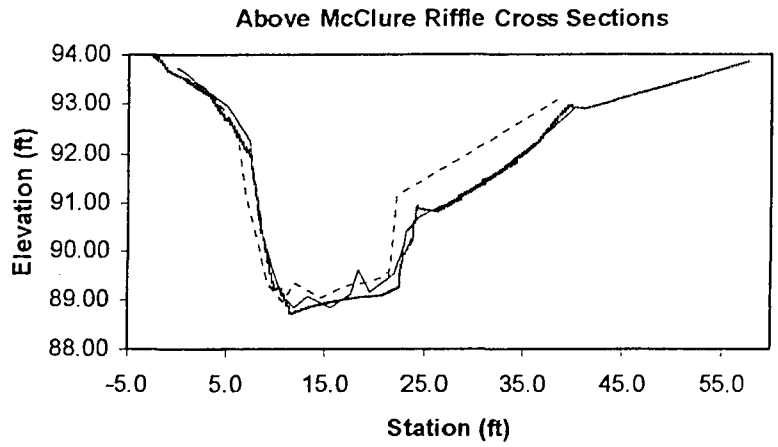
C-5 continued: Geomorphology of Santa Fe River at Wilderness Boundary

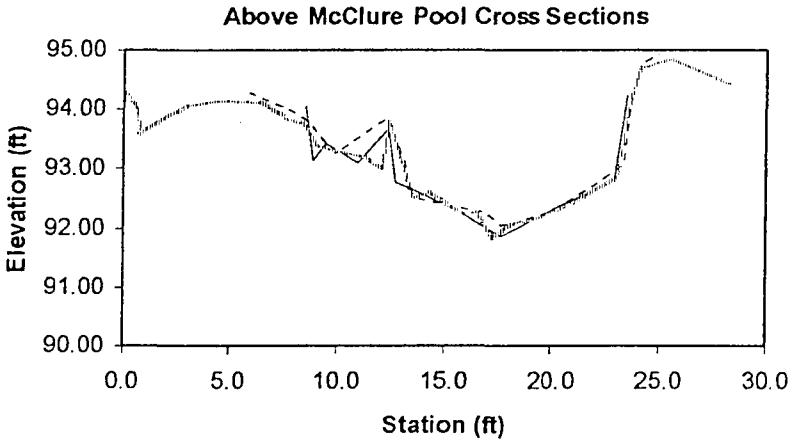


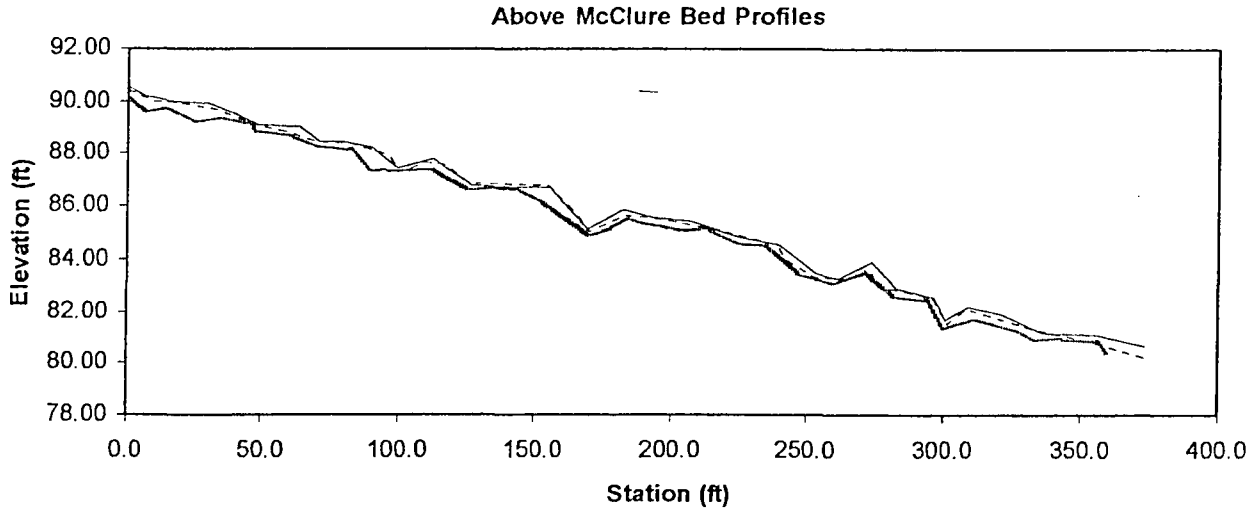




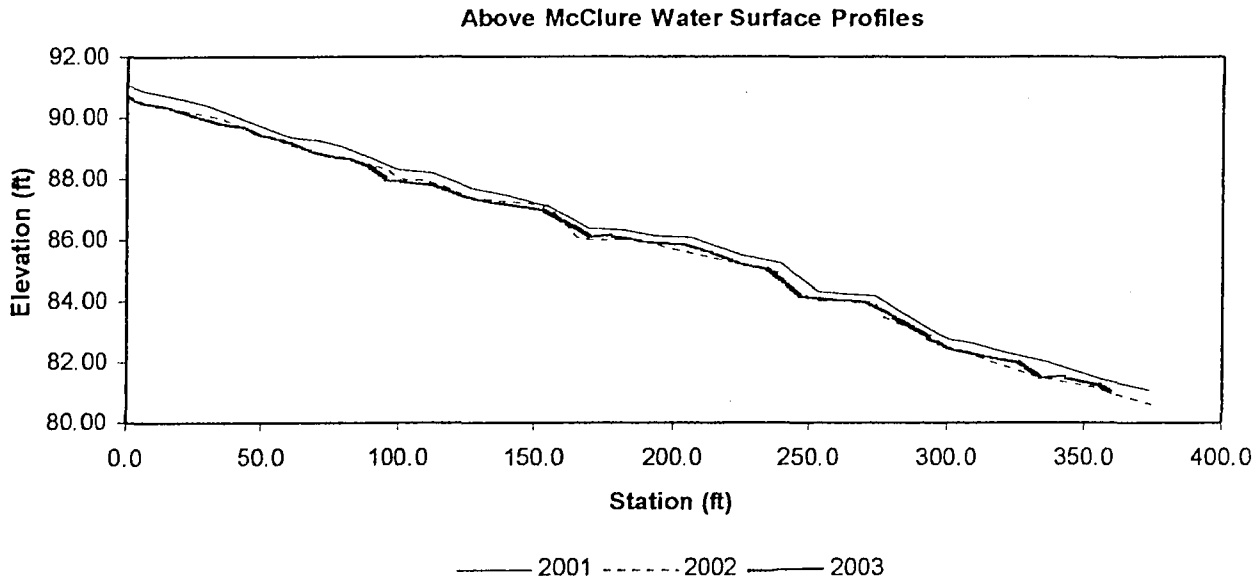


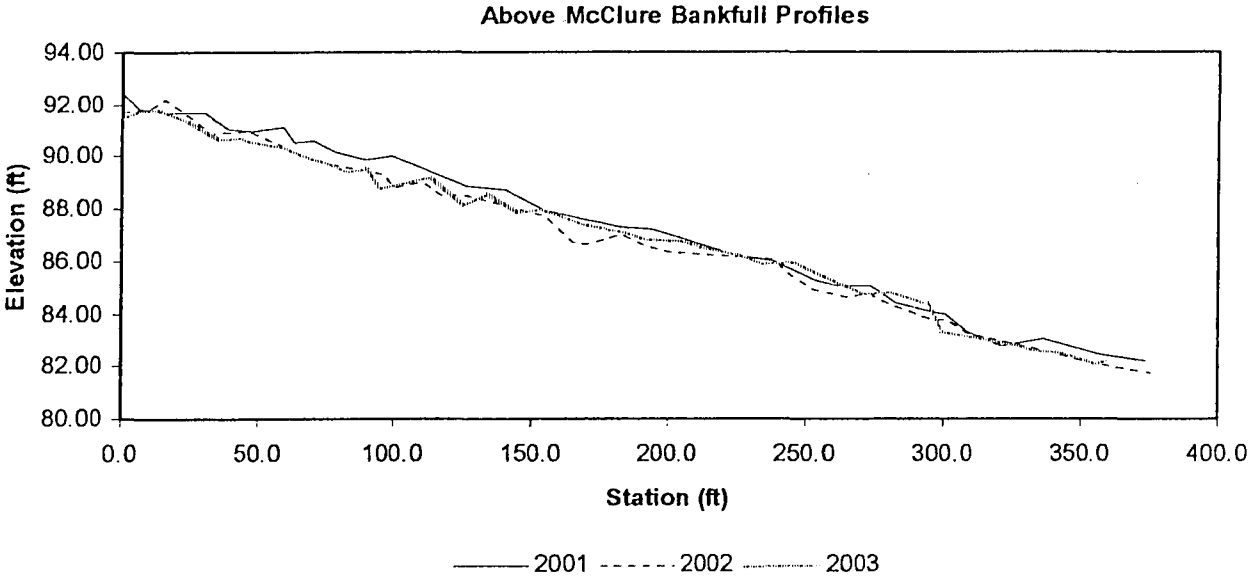

Above McClure Riffle Cross Sections
94.00
93.00
92.00
91.00
90.00
89.00
88.00
Elevation (ft)
-5.0
5.0
15.0
25.0
35.0
45.0
55.0
Station (ft)

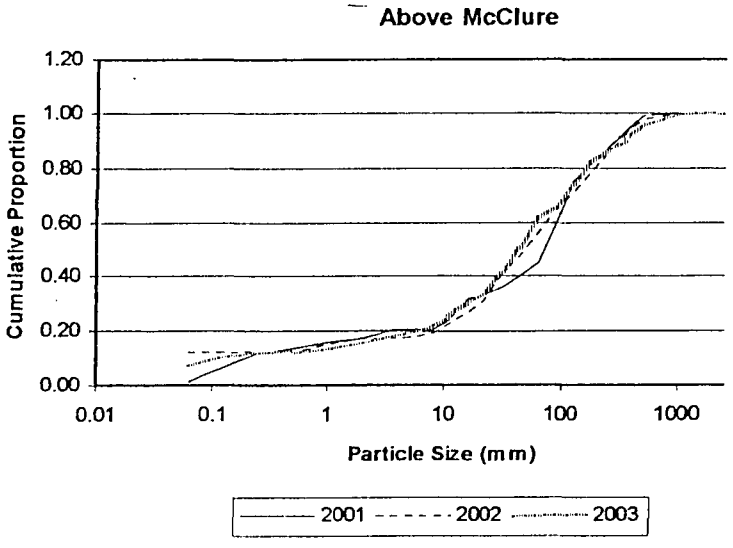

Above McClure Pool Cross Sections
95.00
94.00
93.00
92.00
91.00
90.00
Elevation (ft)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
Station (ft)

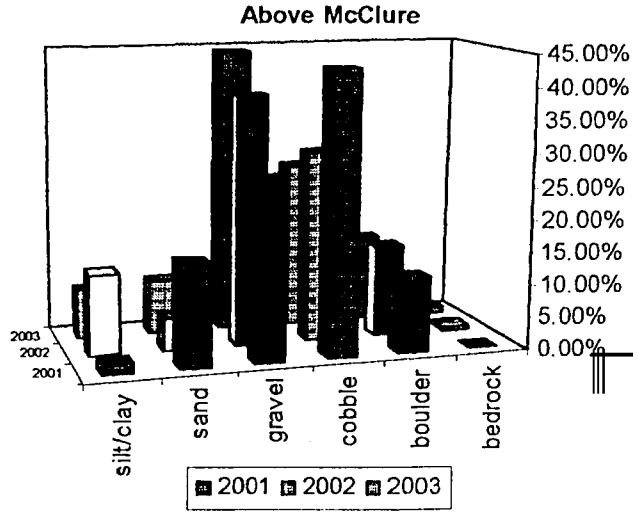

Above McClure Bed Profiles
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
Elevation (ft)
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
Station (ft)
2001
2002
2003

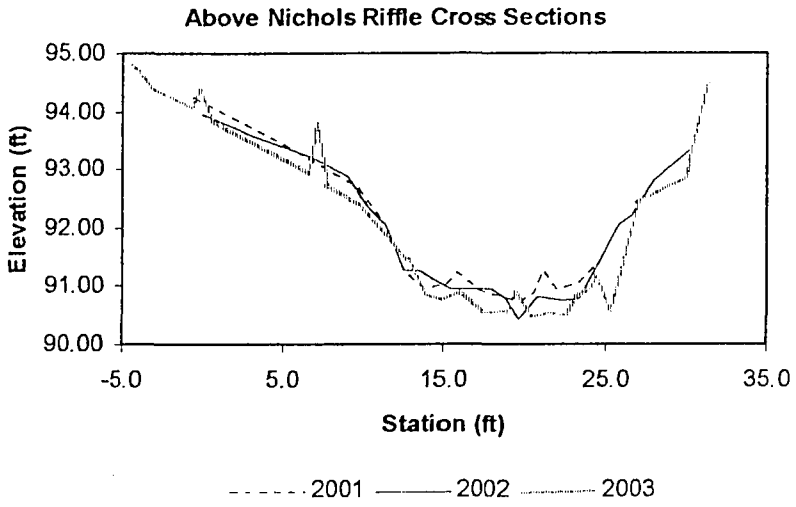
C-5 continued: Geomorphology of Santa Fe River Above McClure Reservoir

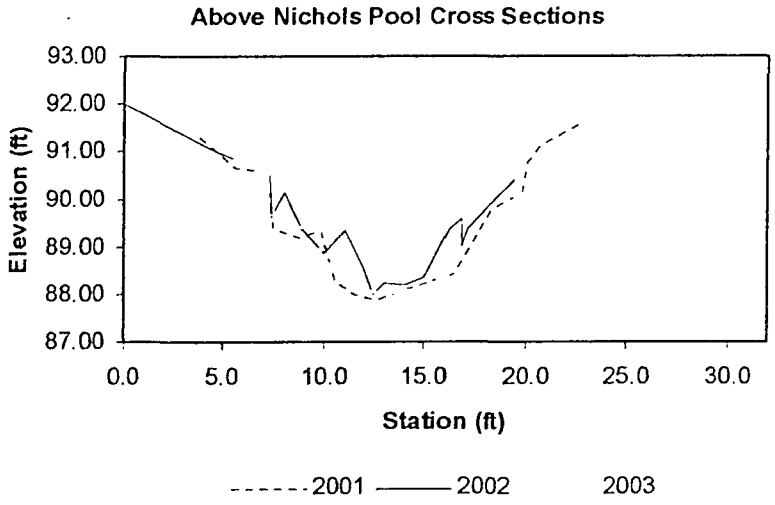


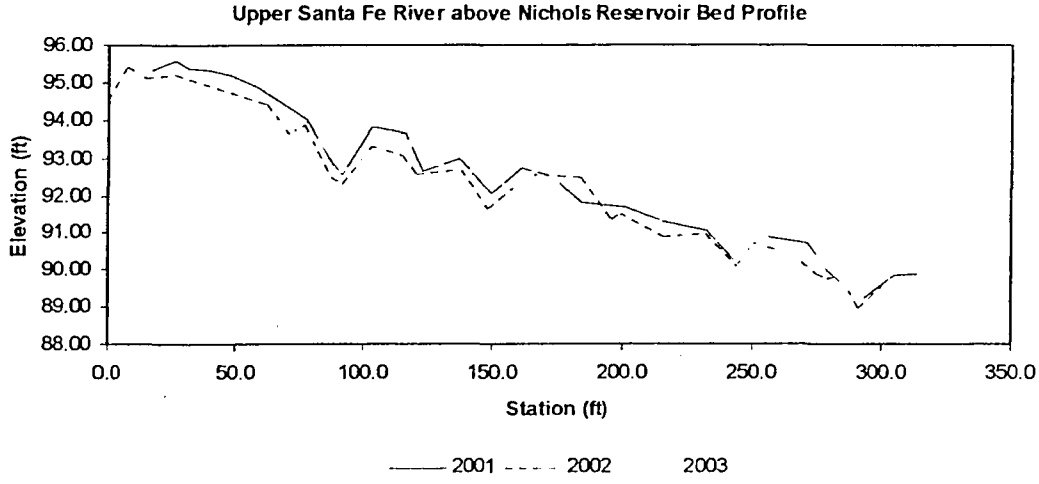


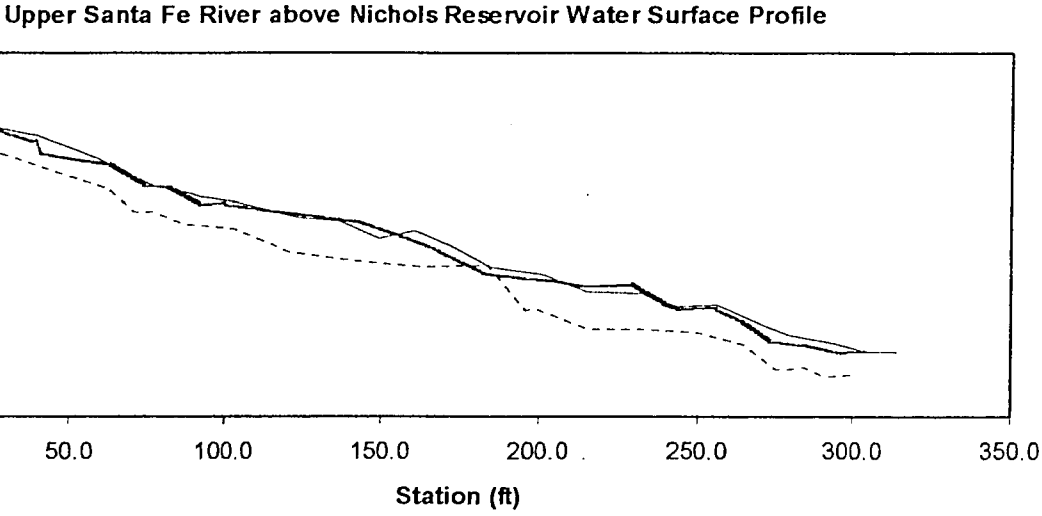


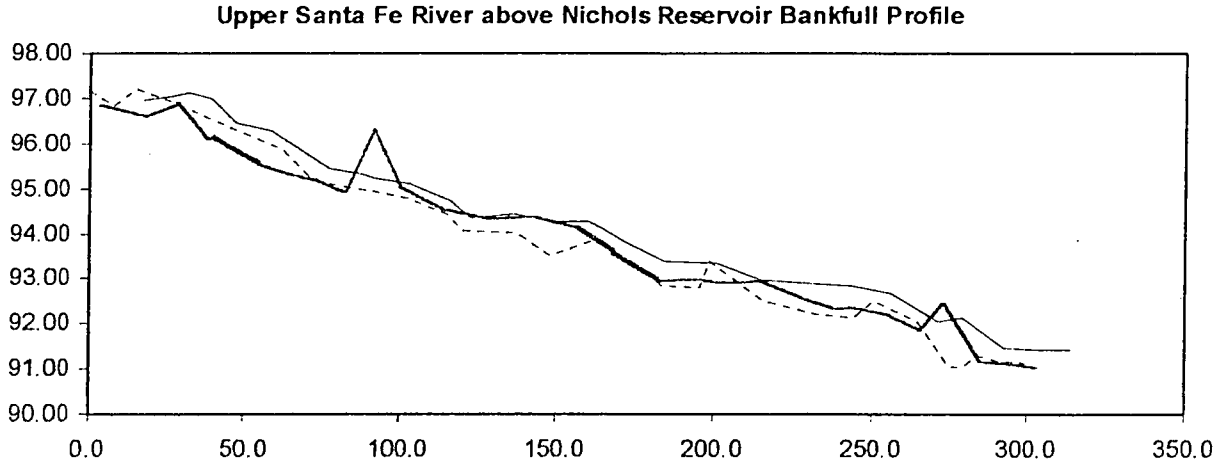



Above Nichols Riffle Cross Sections
95.00
94.00
93.00
92.00
91.00
90.00
Elevation (ft)
-5.0
5.0
15.0
25.0
35.0
Station (ft)
2001
2002
2003

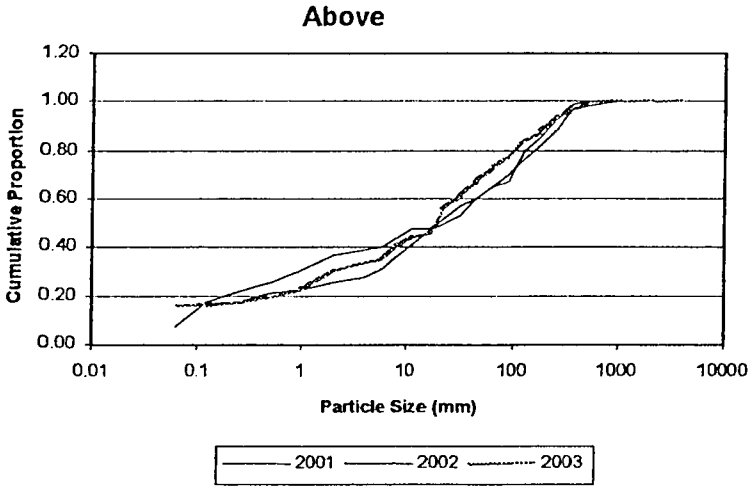

Above Nichols Pool Cross Sections
93.00
92.00
91.00
90.00
89.00
88.00
87.00
Elevation (ft)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
Station (ft)
2001
2002
2003

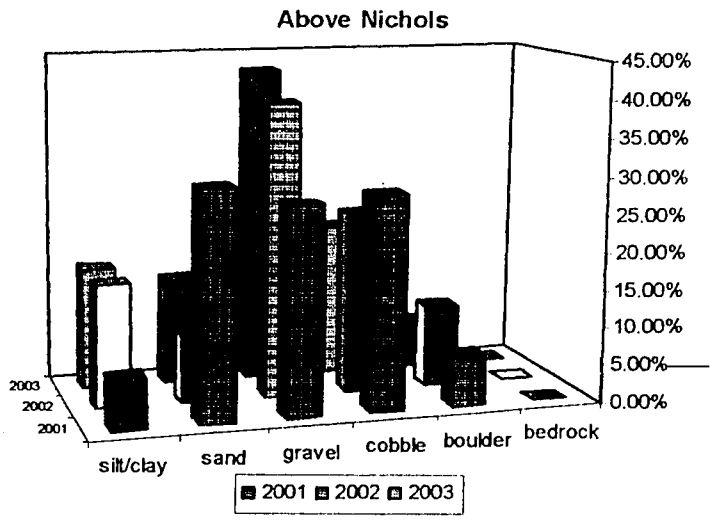

Upper Santa Fe River above Nichols Reservoir Bed Profile
96.00
95.00
94.00
93.00
92.00
91.00
90.00
89.00
88.00
Elevation (ft)
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
Station (ft)
2001
2002
2003





2001 2002 2003





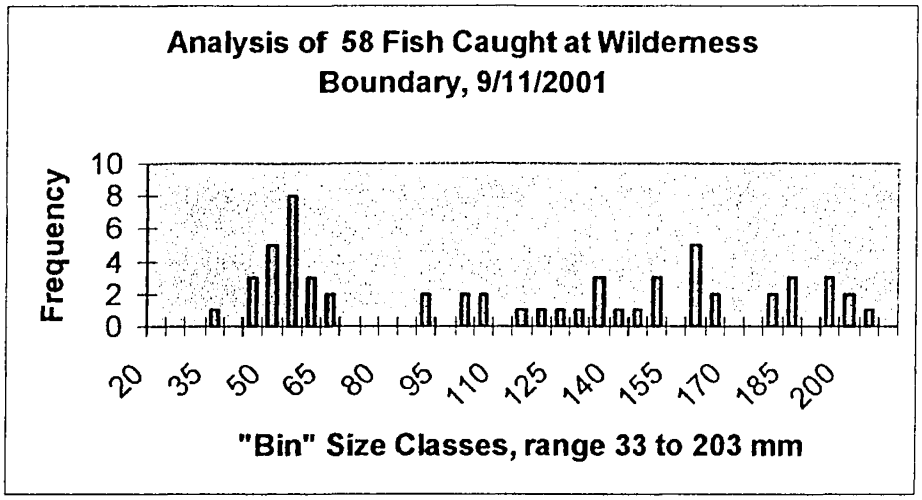
C-6: Benthic Macroinvertebrate Analysis, Santa Fe River at 3 Riparian Study Sites

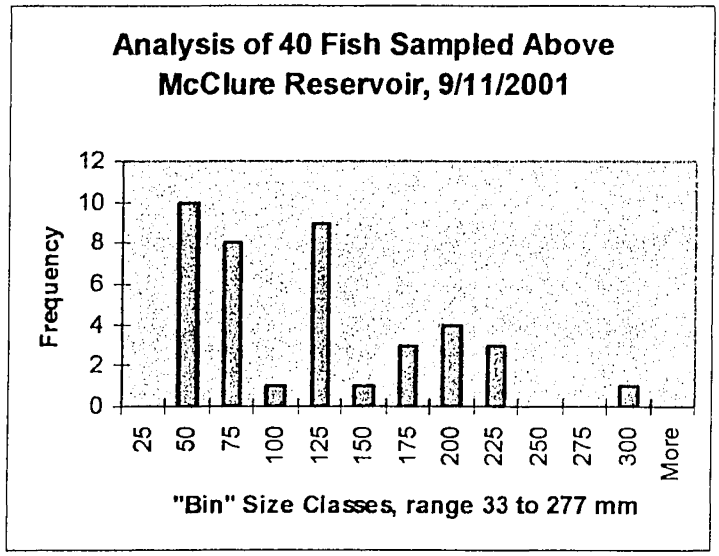
	Santa Fe River Pecos Wilderness Boundary 1 Nov. 2001 35 42' 23.7" 105 48' 17.8"	Santa Fe River Above McClure Reservoir 1 Nov. 2001 35° 41' 19.7" 105° 49' 26.9"	Santa Fe River Above Nichols Reservoir 1 Nov. 2001 35° 41' 12" 105° 51' 32"
Ephemeroptera - mayflies			
Baetidae			
Baetis sp.	79		62
Heptageniidae			
Cinygmula sp.	18	40	1
Epeorus sp.	12	17	
Ephemerellidae			
Drunella sp.	5	5	
Ephemerella sp.	47	17	51
Leptophlebiidae			
Paraleptophlebia sp.		7	40
Plecoptera - stoneflies			
Nemouridae			
Zapada sp.	12	9	5
Perlidae			
Claassenia sp.		12	6
Hesperoperla sp.	8		
Perlodidae	8	10	
Megarcys sp.	6		
Chloroperlidae	10	6	
Suwallia sp.	9		
Sweltsa sp.	16	10	4
Trichoptera - caddisflies			
Hydropsychidae			
Arctopsyche sp.	14	11	
Hydropsyche sp.	27	27	3
Rhyacophilidae			
Rhyacophila sp.	9	6	
Lepidostomatidae			
Lepidostoma sp.	5	9	21
Coleoptera - beetles			
Elmidae			
Cleptelmis sp.			2
Optioservus sp.	11	19	12
Diptera - true flies			
Ceratopogonidae	1		
Chironomidae			
Orthocladiinae			
Brillia sp.		6	2
Eukiefferiella sp.		5	2
Chironominae			
Tanytarsini			
Rheotanytarsus sp.	12		
Stempellina sp.		5	
Tanytarsus sp.		5	
Dixidae			
Dixa sp.		13	
Psychodidae			
Pericoma sp.	8		
Simuliidae			
Simulium sp.		19	100
Tipulidae			
Dicranota sp.	6		2
Hexatoma sp.	1		1
Empididae			
Chelifera sp.	5		
Oreogeton sp.	5		
Ostracoda		5	
Number of Individuals	334	263	314
Number of Taxa	24	22	16

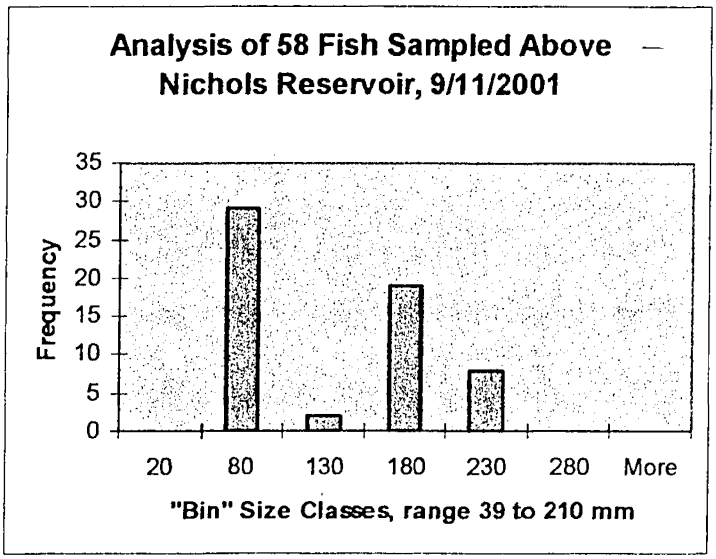
C-6 continued: Benthic Macroinvertebrate Analysis

	Santa Fe River Pecos Wilderness Boundary 1 Nov. 2001 35 42' 23.7" 105 48' 17.8"	Santa Fe River Above McClure Reservoir 1 Nov. 2001 35° 41' 19.7" 105° 49' 26.9"	Santa Fe River Above Nichols Reservoir 1 Nov. 2001 35° 41' 12" 105° 51' 32"
NMED Metrics			
No. of Taxa	24	22	16
EPT	16	14	9
EPT/Chironomidae	23.75	8.857142857	48.25
% Dominant Taxon	23.65269461	15.20912548	31.84713376
Scrapers/Filter Collecters	0.566037736	0.919354839	0.009708738
Shredders/Total	0.050898204	0.091254753	0.089171975
Idaho TV	2.889221557	2.870722433	3.694267516
HBI	2.868263473	2.726235741	3.337579618
Diversity LN	2.725896453	2.887699616	1.955076346
Diversity (LOG Base 2)	3.932637294	4.166069916	2.820578948
Eveness	0.857725073	0.93421545	0.705144737

C-7: Fish Sampled at Santa Fe River at 3 Riparian Study Sites on the Santa Fe River, Santa Fe Municipal Watershed

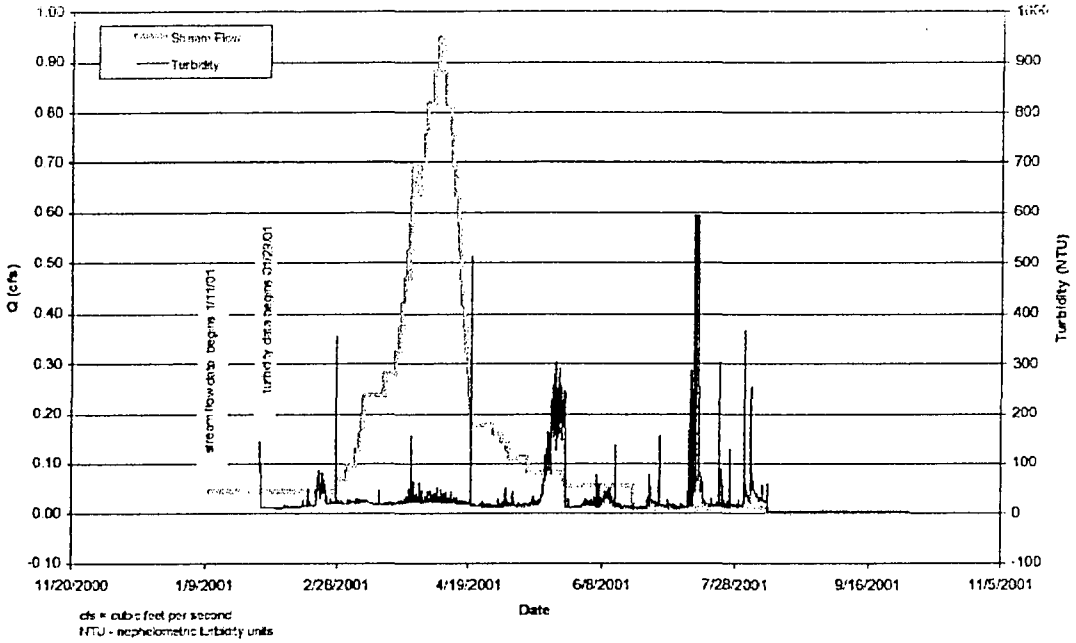






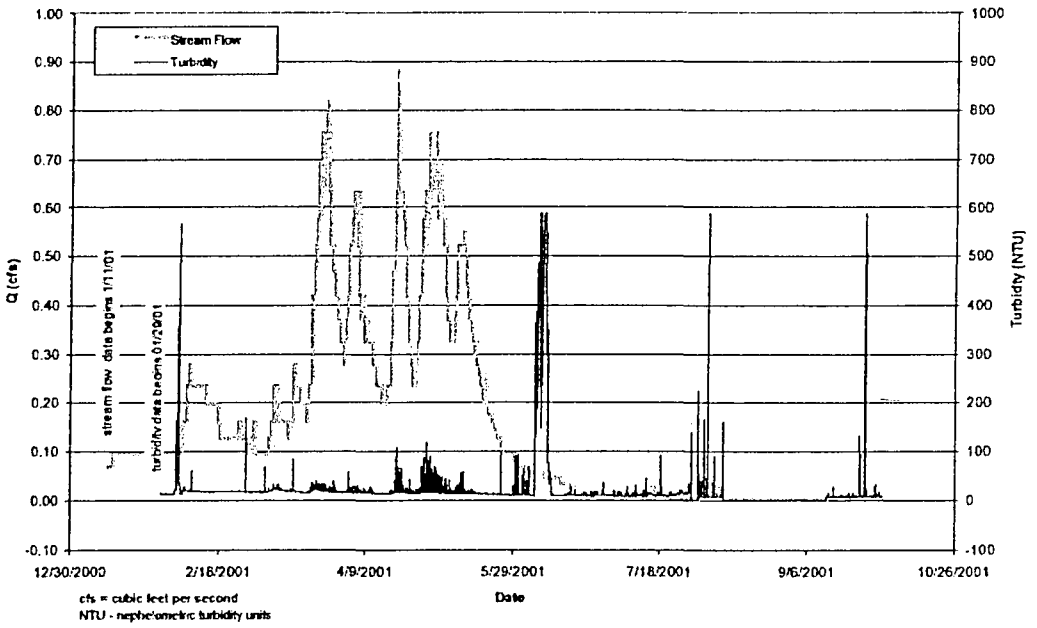
ATTACHMENT D:

Paired Basin Hydrographs,
Water Years 2001 through 2003



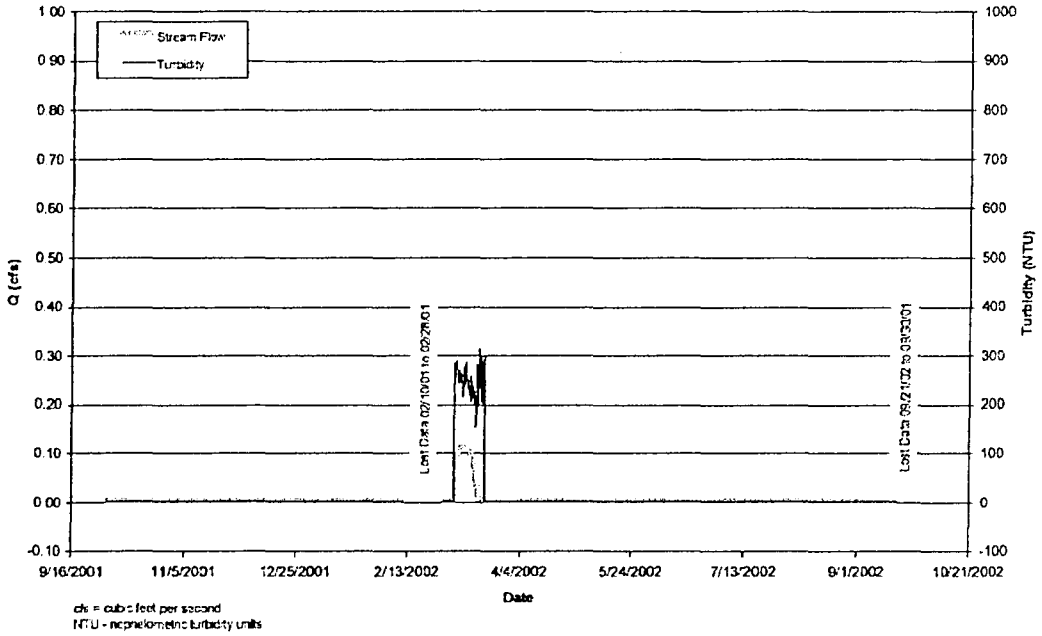
WATERSHED WEST

PAIRED BASIN STUDY - TREATED (Provisional Data)
Stream Flow vs. Turbidity
1/11/01 to 9/30/01



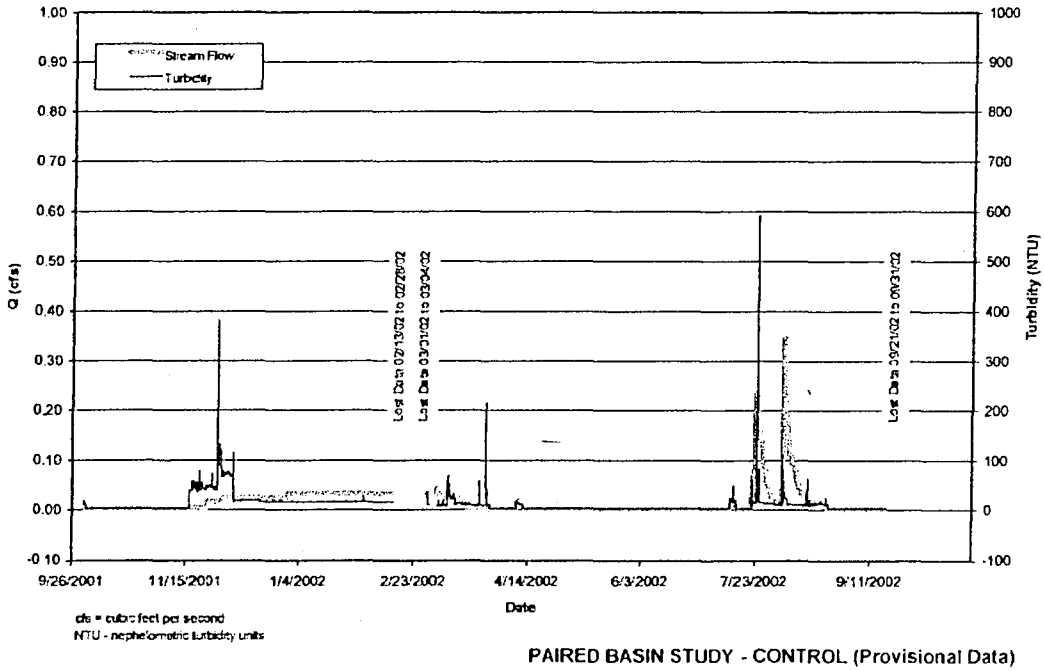
WATERSHED WEST

PAIRED BASIN STUDY - CONTROL (Provisional Data)
Stream Flow vs. Turbidity
1/11/01 to 9/30/01



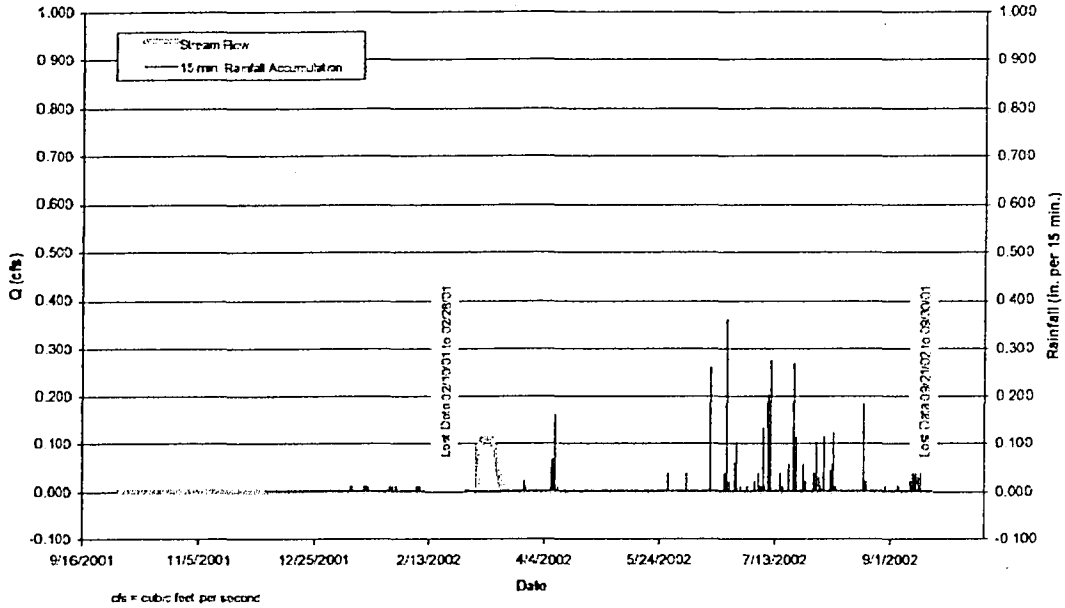
WATERSHED WEST

PAIRED BASIN STUDY - TREATED (Provisional Data)
Stream Flow vs. Turbidity
10/1/2001 to 9/30/02



WATERSHED WEST

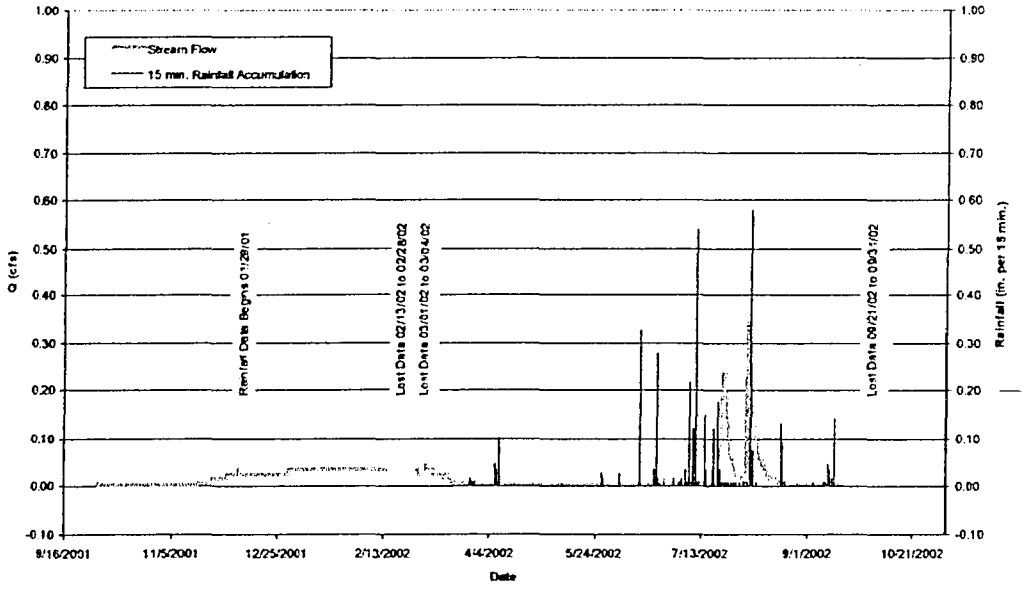
PAIRED BASIN STUDY - CONTROL (Provisional Data)
Stream Flow vs. Turbidity
10/1/2001 to 9/30/2002



cfs = cubic feet per second
in - inches
min - minutes

WATERSHED WEST

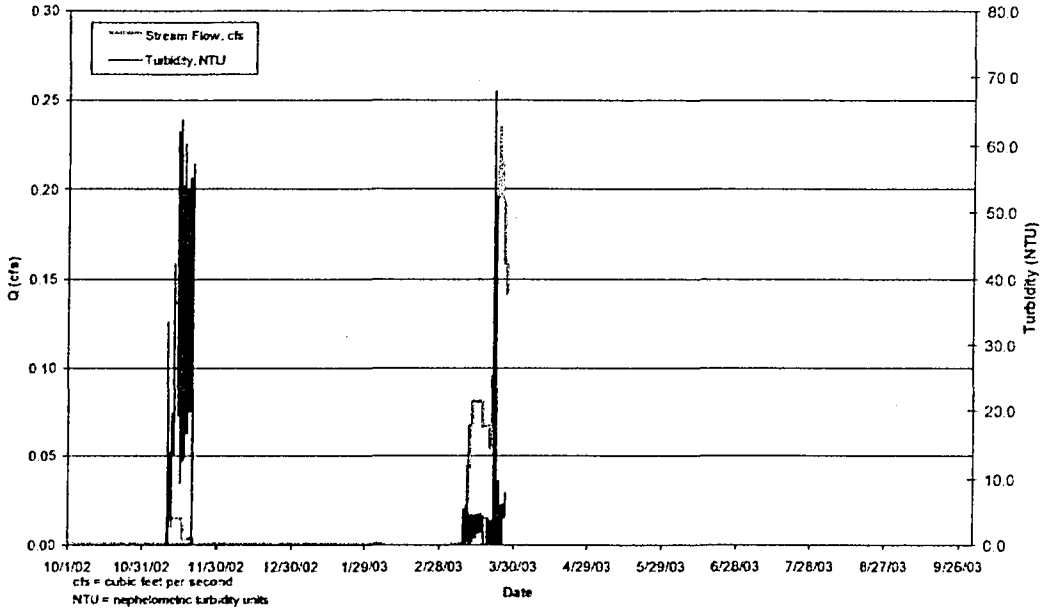
PAIRED BASIN STUDY - TREATED (Provisional Data)
Stream Flow vs. 15 min. Rainfall Accumulation
10/01/01 to 9/30/02



cfs = cubic feet per second
in-inches
min-minutes

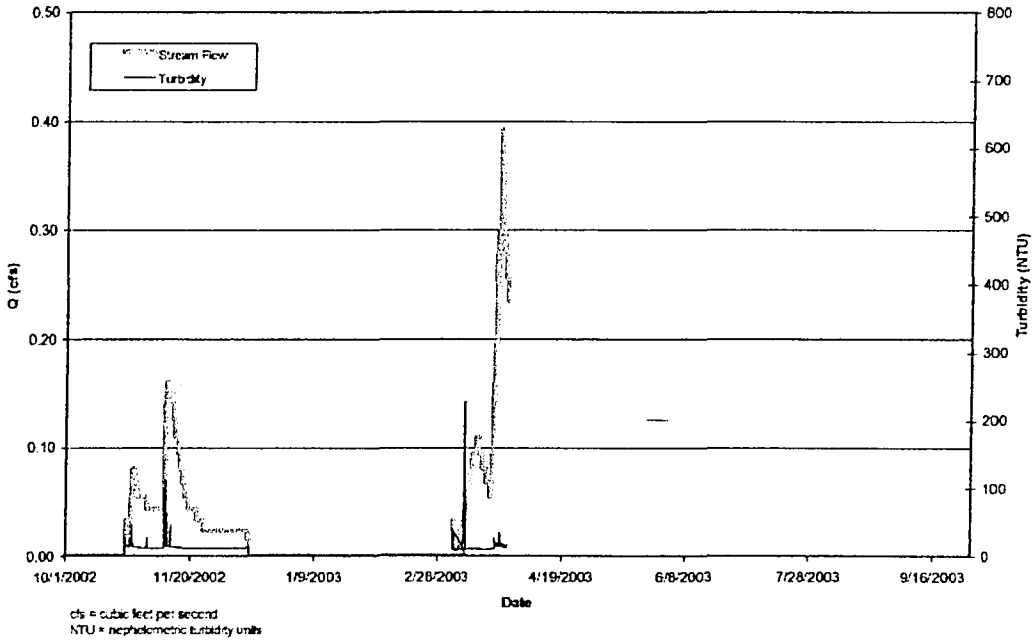
WATERSHED WEST

PAIRED BASIN STUDY - CONTROL (Provisional Data)
Stream Flow vs. 15 min. Rainfall Accumulation
10/1/01 to 9/30/02



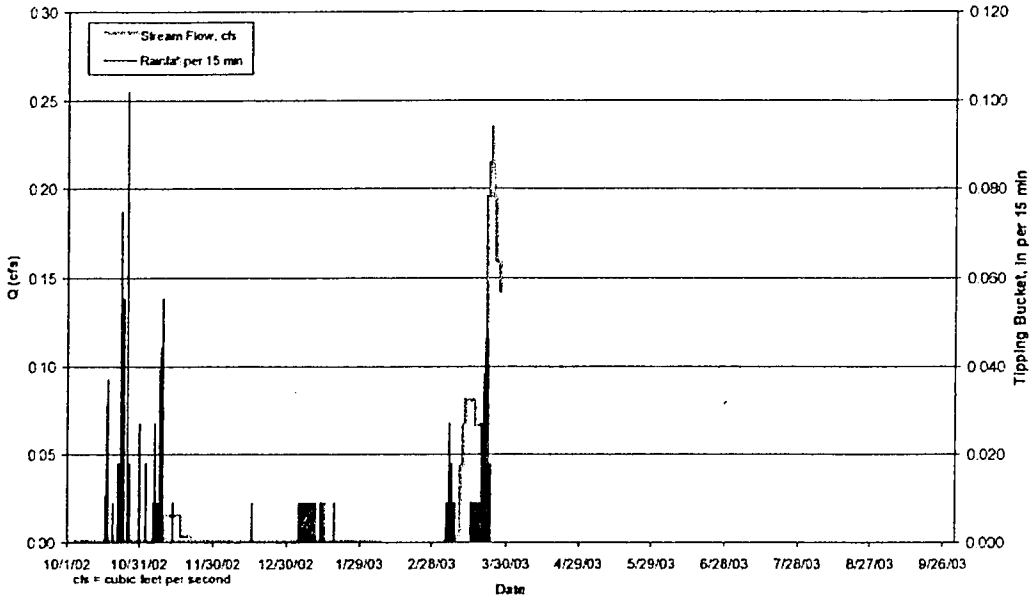
WATERSHED WEST

PAIRED BASIN STUDY - TREATED (Provisional Data)
Stream Flow vs. Turbidity
WY 2003



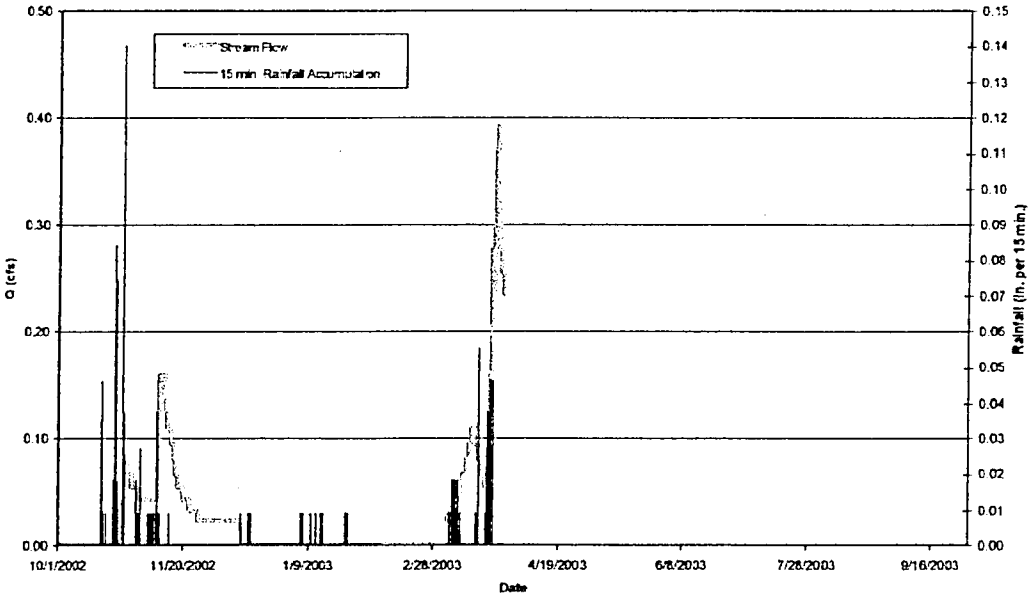
WATERSHED WEST

PAIRED BASIN STUDY - CONTROL
Stream Flow vs. Turbidity
WY 2003 (Provisional Data)



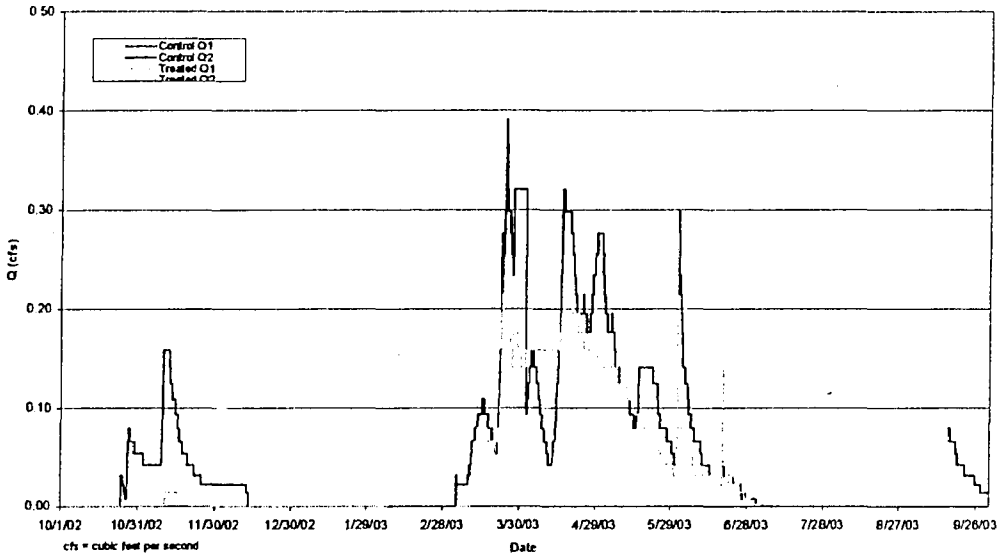
WATERSHED WEST

PAIRED BASIN STUDY - TREATED (Provisional Data)
Stream Flow vs. 15 min. Rainfall Accumulation
WY 2003



WATERSHED WEST

PAIRED BASIN STUDY - CONTROL
Stream Flow vs. 15 min. Rainfall Accumulation
WY 2003 **(Provisional Data)**



WATERSHED WEST

PAIRED BASIN STUDY -
Control & Treated Stream Flow
WY 2003 (Provisional Data)

ATTACHMENT E:

Tables and Graphs of 2003 Wildlife Study Results
Rocky Mountain Research Station

Table 1: List of bird species that were observed on point counts in 2002 and 2003 from May to September and the total number of sightings for each species across all points.

Common name	Scientific name	# Obs 2002	# Obs 2003
Mallard	***Anas platyrhynchos***	3	0
Turkey Vulture	***Cathartes aura***	10	8
Sharp-shinned Hawk	***Accipiter striatus***	6	0
Cooper's Hawk	*Accipiter cooperii*	1	7
Red-tailed Hawk	*Buteo jamaicensis*	6	2
Osprey	*Pandion haliaetus*	0	2
Hawk species		1	2
American Kestrel	***Falco sparverius***	1	0
Wild Turkey	***Meleagris gallopavo***	4	3
Mourning Dove	***Zenaida macroura***	64	15
Flammulated Owl	***Otus flammeolus***	0	5
Common Nighthawk	***Chordeiles minor***	0	25
Common Poorwill	***Phalaenoptilus nuttallii***	0	2
White-throated Swift	***Aeronautes saxatalis***	0	3
Black-chinned Hummingbird	***Archilochus alexandri***	6	0
Broad-tailed Hummingbird	***Selasphorus platycercus***	86	119
Hummingbird species		2	4
Belted Kingfisher	***Ceryle alcyon***	2	0
Red-naped Sapsucker	***Sphyrapicus nuchalis***	6	14
Williamson's Sapsucker	*Sphyrapicus thyroideus*	11	20
Downey Woodpecker	*Picoides pubescens*	5	4
Hairy Woodpecker	*Picoides villosus*	53	45
Northern Flicker	*Colaptes auratus*	135	137
Woodpecker species		14	13
Olive-sided Flycatcher	***Contopus borealis***	5	10
Western-wood Pewee	*Contopus sordidulus*	17	52
Dusky Flycatcher	*Empidonax oberholseri*	21	26
Gray Flycatcher	***Empidonax wrightii***	0	14
Pacific-slope Flycatcher	***Empidonax difficilis***	0	4
Cordilleran Flycatcher	***Empidonax occidentalis***	38	59
Ash-throated Flycatcher	***Myiarchus cinerascens***	3	4
Flycatcher species		22	14
Violet-green Swallow	***Tachycineta thalassina***	16	17
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	3	0
Swallow species		19	1
Steller's Jay	***Cyanocitta stelleri***	416	137
Western Scrub Jay	*Aphelocoma californica*	1	0
Pinyon Jay	*Gymnorhinus cyanocephalus*	124	1
Jay species		4	0
Clarks Nutcracker	*Nucifraga columbiana*	253	35
Black-billed Magpie	*Pica hudsonia*	0	1
Common Raven	*Corvus corax*	152	126
Mountain Chickadee	***Parus gambeli***	596	491
Bushtit	*Psaltriparus minimus*	37	7
White-breasted Nuthatch	*Sitta canadensis*	82	180
Red-breasted Nuthatch	*Sitta carolinensis*	454	64
Pygmy Nuthatch	*Sitta pygmaea*	230	327
Nuthatch species		2	1
Brown creeper	***Certhia americana***	11	61
House Wren	***Troglodytes aedon***	7	12
Golden-crowned Kinglet	*Regulus satrapa*	2	5
Ruby-crowned Kinglet	*Regulus calendula*	54	1
Western Bluebird	***Sialia mexicana***	12	16
Hermit Thrush	*Catharus guttatus*	222	169
Townsend's solitaire	*Myadestes townsendi*	32	49
American Robin	***Turdus migratorius***	113	119
Plumbeous Vireo	*Vireo Plumbeus*	5	8

Warbling Vireo	*Vireo gilvus*	64	182
Orange-crowned Warbler	***Vermivora celata***	1	0
Nashville Warbler	*Vermivora ruficapilla*	1	0
Virginia's Warbler	*Vermivora virginiae*	10	5
Yellow Warbler	*Dendroica petechia*	0	18
Black-throated Gray Warbler	*Dendroica nigrescens*	0	1
Yellowrumped Warbler	*Dendroica coronata*	176	183
Townsend's Warbler	*Dendroica townsendi*	1	0
Grace's Warbler	*Dendroica graciae*	60	133
MacGillvray's Warbler	*Oporornis tolmiei*	9	11
Wilson's Warbler	*Wilsonia pusilla*	17	2
Warbler species		5	2
Western Tanager	***Piranga ludoviciana***	28	62
Black-headed Grosbeak	*Pheucticus melanocephalus*	27	28
Spotted Towhee	*Pipilo maculatus*	13	16
Chipping Sparrow	***Spizella passerina***	11	103
Song Sparrow	*Melospiza melodia*	4	0
Dark-eyed Junco	*Junco hyemalis*	292	255
Brown-headed Cowbird	***Molothrus ater***	1	0
Red Crossbill	***Loxia curvirostra***	0	6
Evening Grosbeak	***Coccothraustes vespertinus***	99	0
House Finch	*Carpodacus mexicanus*	46	0
Pine Siskin	*Carduelis pinus*	72	46
Lesser Goldfinch	*Carduelis psaltria*	7	1
American Goldfinch	***Carduelis tristis***	3	2
Finch species		3	0
Unknown species		101	196
		4319	3693

Table 2. Changes in density with percent coefficient of variation for the 14 most abundant bird species across years (2002-2003) between treatment and reference areas.

	2002				2003			
	Reference		Treatment		Reference		Treatment	
Species	d[1]	%CV[2]	d	%CV	d	%CV	d	%CV
All birds	13.74	8.59	15.41	5.22	13.69	8.11	12.86	5.39
Broad-tailed hummingbird	1.14	31.55	1.83	22.88	0.92	50.93	2.18	28.54
Northern flicker	0.14	25.82	0.13	24.72	0.15	23.58	0.24	21.57
Steller's jay	.034	15.72	.054	18.08	.030	28.06	0.13	16.42
Common raven	0.08	22.15	0.07	23.47	0.72	40.66	0.86	27.4
Mountain chickadee	3.95	14.77	3.22	9.62	1.82	15.49	1.61	11.05
White-breasted nuthatch	0.24	33.6	0.20	21.87	0.12	26.9	0.22	13.74
Red-breasted nuthatch	2.24	19.88	1.01	8.63	0.05	40.29	0.02	33.98
Pygmy nuthatch	0.74	32.46	1.11	17.72	0.35	22.30	1.61	13.92
Hermit thrush	0.16	22.50	0.09	15.52	0.09	36.19	0.17	15.73
American robin	0.51	26.01	0.12	21.34	0.26	24.34	0.32	19.89
Warbling vireo	0.07	26.00	0.06	28.44	1.03	23.18	0.79	18.81
Yellow-rumped warbler	0.58	23.26	2.00	18.7	0.83	20.19	0.77	16.75
Western tanager	0.04	36.58	0.08	33.31	0.28	46.26	0.30	26.12
Dark-eyed junco	2.67	22.79	1.58	13.08	1.96	22.24	1.84	10.22

Table 3. Number and species of owls observed by using call and response playback in 2003.

	Flammulated owl	Northern pygmy owl	Northern saw-whet owl	Western screech owl	Mexican spotted owl	Great horned owl	Total for each area
Treatment areas	1	0	2	1	0	1	5
Reference areas	5	1	0	0	0	1	7
Total	6	1	2	1	0	2	12

[1] Density in birds per hectare

[2] Percent coefficient of variation of the density estimate

Table 4. Nest fate across years (2002-2003) and between treatment and reference areas.

	2002				2003			
	All	Success	Fail	Unk	All	Success	Fail	Unk
Treatments	13	5	3	5	8	5	2	1
References	3	2	0	1	15	13	2	0
Total	16	7	3	6	23	18	4	1

Table 5. Mammal species and number of individuals that were trapped across years (2002-2003) between treatment and reference areas on upland webs and riparian transects.

		2002				2003			
		Web		Transect		Web		Transect	
Scientific Name	Common name	T	R	T	R	T	R	T	R
Long-tailed vole	*Microtus longicaudus*	0	0	3	31	0	1	22	55
Meadow vole	*Microtus pennsylvanicus*	0	0	0	17	0	3	9	38
Heather vole	*Phenacomys intermedius*	0	0	0	1	0	0	0	0
Southern red-backed vole	*Clethrionomys gapperi*	0	1	1	1	0	0	0	0
White-throated wood rat	*Neotoma albigula*	0	0	0	0	5	1	0	9
Mexican woodrat	*Neotoma mexicana*	4	3	20	7	8	4	76	5
Deer mouse	*Peromyscus maniculatus*	41	54	122	118	94	125	244	290
White-footed mouse	*Peromyscus leucopus*	0	0	2	2	0	0	6	3
Brush mouse	*Peromyscus boylii*	0	0	0	1	0	0	0	0
Western harvest mouse	*Reithrodontomys megalotis*	0	0	1	0	0	0	2	0
Shrew species	*Sorex* species	0	0	0	3	0	0	1	2
Golden-mantled ground squirrel	*Spermophilus lateralis*	0	1	1	1	0	1	1	5
Least chipmunk	*Tamias minimus*	8	6	0	1	17	11	0	5
Colorado chipmunk	*Tamias quadrivittatus*	0	0	0	0	2	1	0	0
Red squirrel	*Tamiasciurus hudsonicus*	0	0	1	0	0	0	0	0
Western jumping mouse	*Zapus princeps*	0	0	2	17	0	0	4	12
Number of individuals trapped		53	65	150	152	126	147	365	424
Individual/trapnight X 100		2.79	3.44	8.48	13.48	6.71	5.29	21.12	25.60
Number of species		3	5	9	12	6	8	9	10

Table 6. Number of arthropod individuals and individuals per point collected and identified to Family compared across years and between treatment and reference areas. Chart includes indication of change in number of Orders and Families identified across years (2002-2003).

	Treatments		References		Classes	Orders	Families
	n[3]	ind/point[4]	n	ind/point			
2002	3964	47.76	1274	79.63	2	6	14
2003	4727	54.33	3082	88.06	2	15	82

[3] Number of individuals

[4] Individuals per vegetation plot, 87 treatment and 35 reference plots.

Figure 1. Avian species diversity index, across years (2002-2003) between treatment and reference areas.

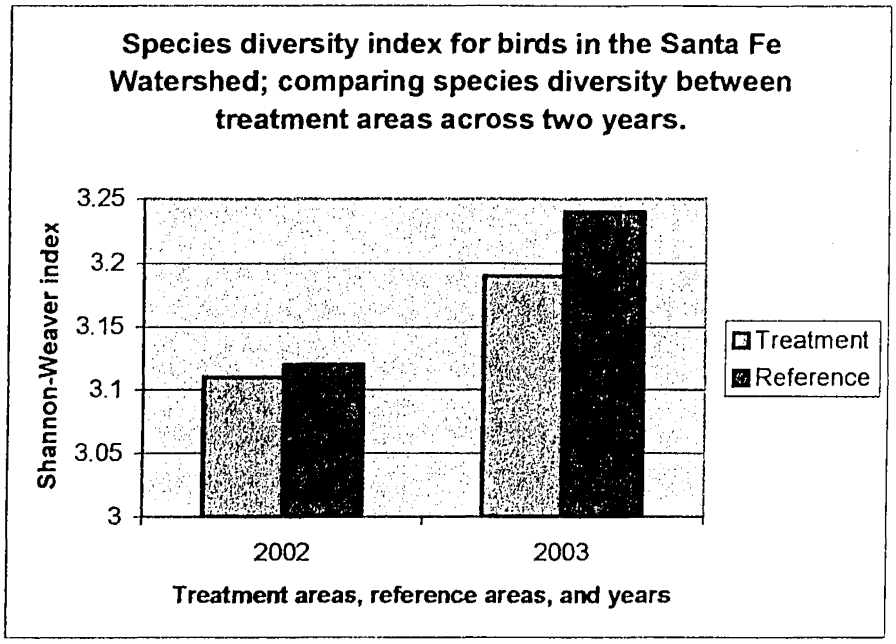


Figure 2. Changes in density across years (2002-2003) between treatment and reference areas for all birds.

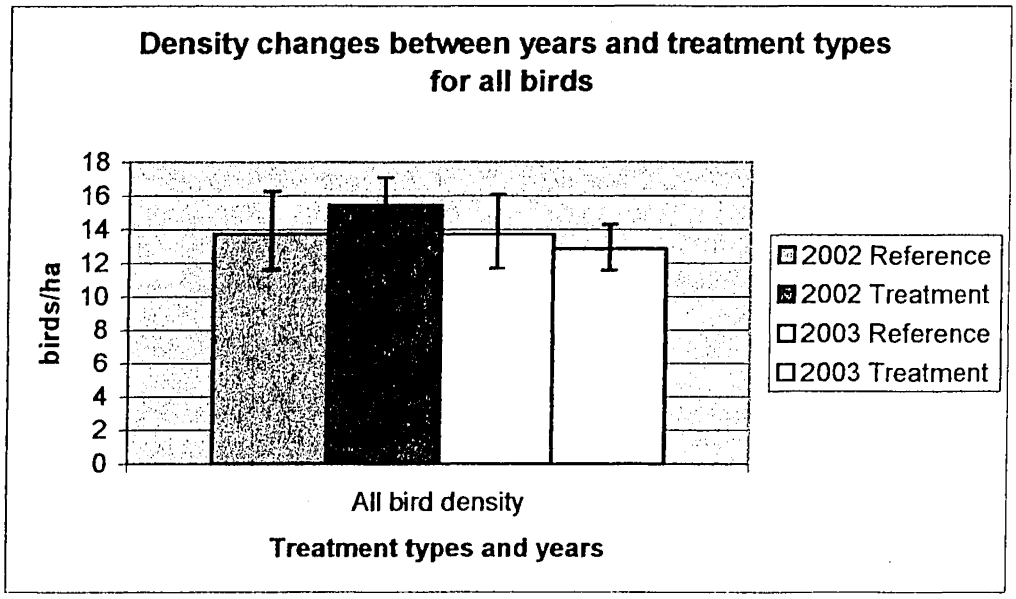


Figure 3. Changes in density across years (2002-2003) between treatment and reference areas for broad-tailed hummingbird.

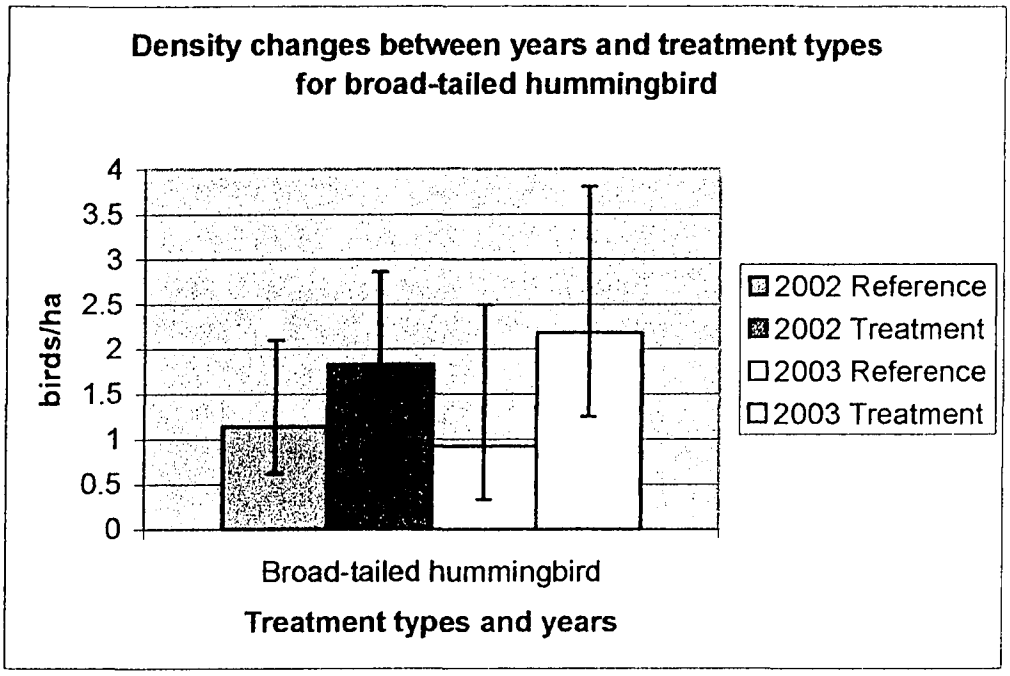


Figure 4. Changes in density across years (2002-2003) between treatment and reference areas for mountain chickadee.

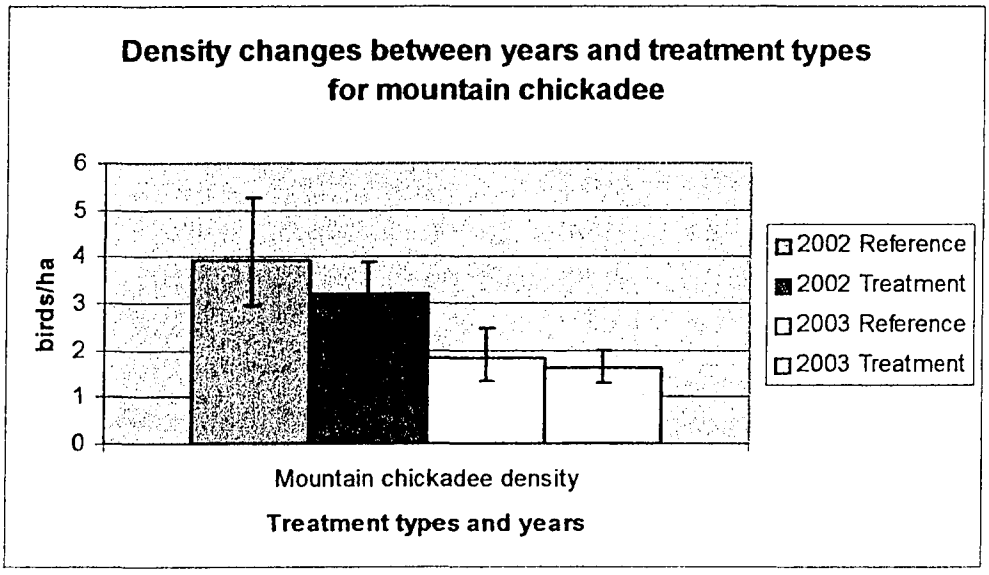


Figure 5. Changes in density across years (2002-2003) between treatment and reference areas for white-breasted nuthatch.

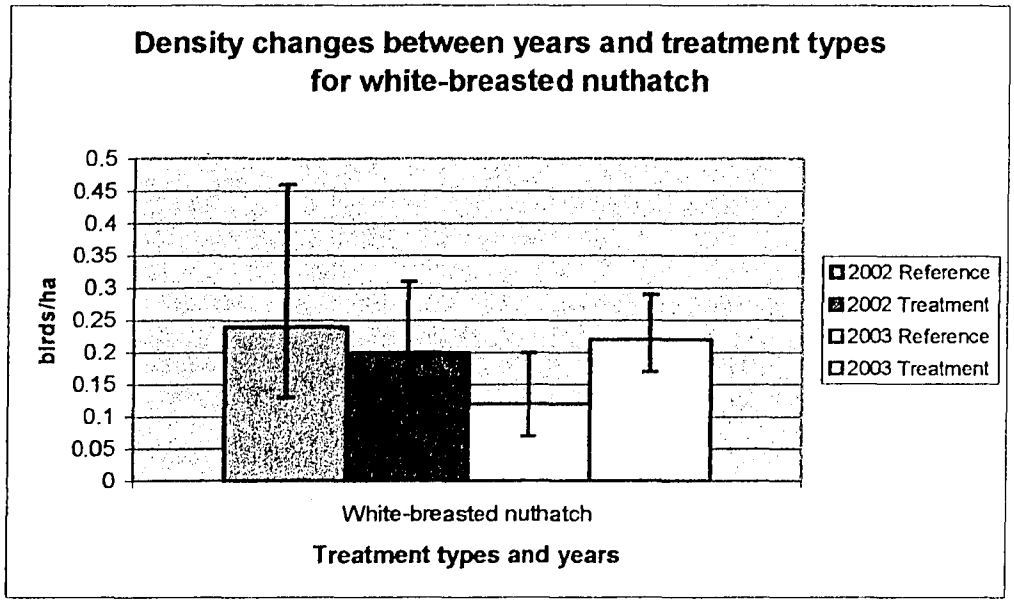


Figure 6. Changes in density across years (2002-2003) between treatment and reference areas for pygmy nuthatch.

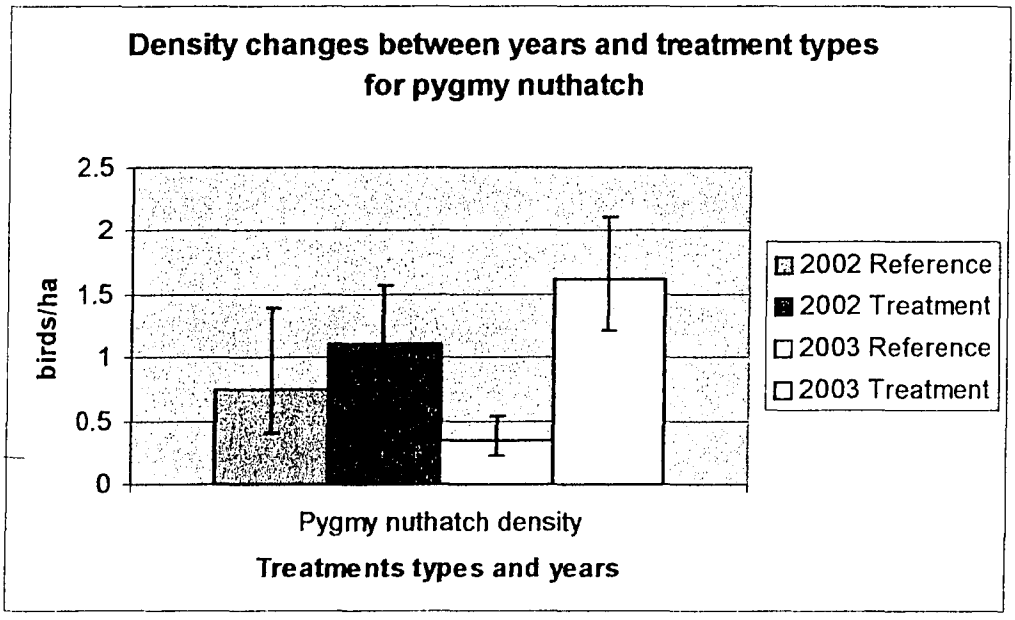


Figure 7. Changes in density across years (2002-2003) between treatment and reference areas for warbling vireo.

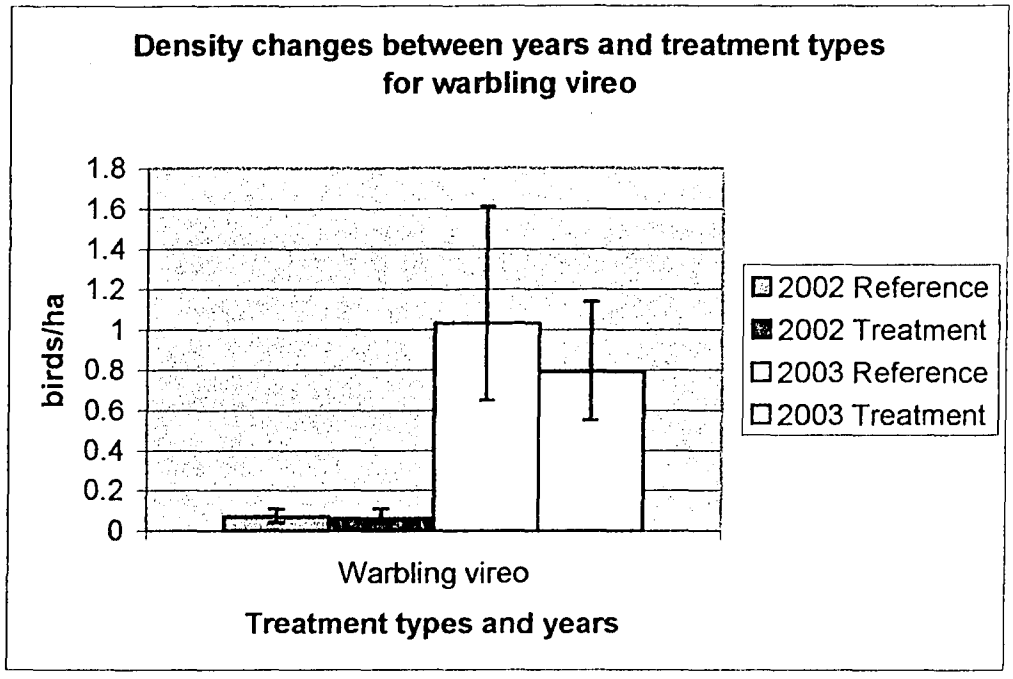


Figure 8. Changes in density across years (2002-2003) between treatment and reference areas for yellow-rumped warbler.

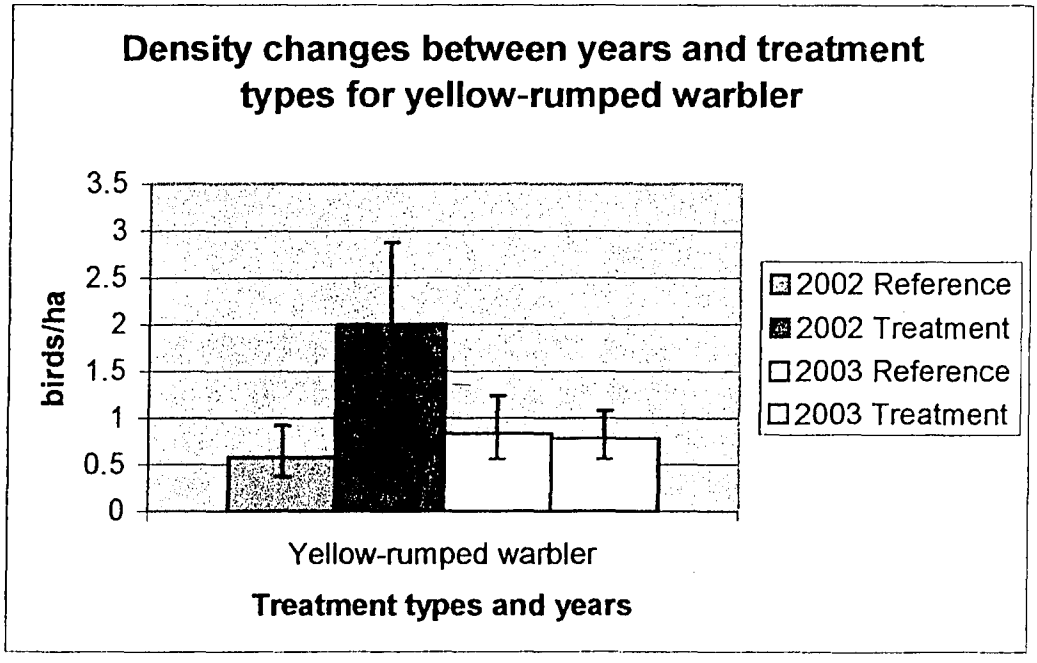


Figure 9. Changes in density across years (2002-2003) between treatment and reference areas for dark-eyed junco.

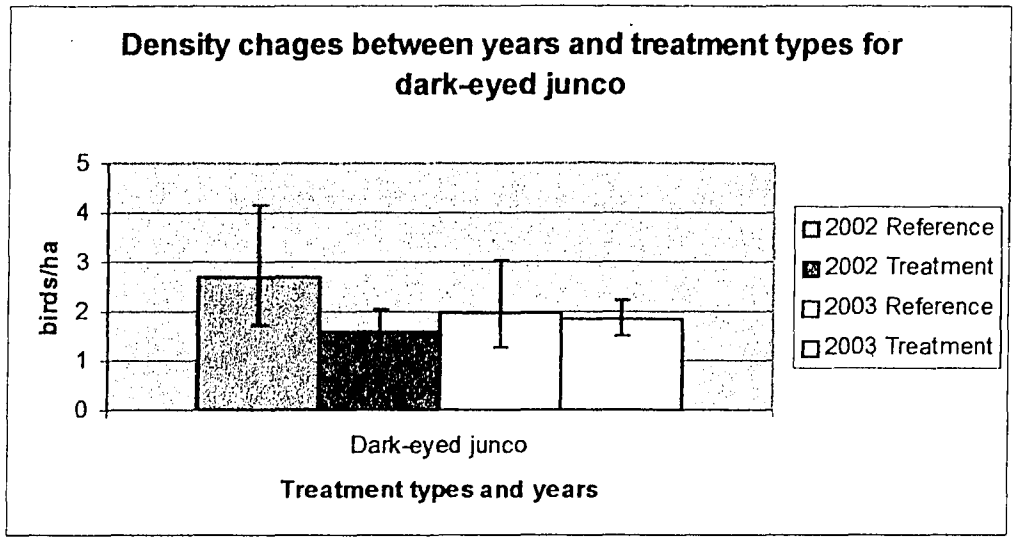


Figure 10. Mammal species diversity index, across years (2002-2003) between treatment and reference areas.